THE *Petroleum* Engineer — Management Edition

Exploration—Drilling—Producing • Refining—Petrochemicals—Gas Processing • Oil and Gas Pipelining

MARCH, 1955 • VOLUME XXVII • NUMBER 3

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The Petroleum Engineer, published monthly, August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, 800 Davis Building, Dallas, Texas. Subscription rate to the Petroleum Industry, United States and Foreign, $5.00 per year, $8.00 for two years; $1.00 for single copy. Entered as second-class mail matter May 1, 1932, at the post office in Dallas, Texas, under the act of March 3, 1879.

XUM

An Enlightened Oil Policy

THE petroleum industry in Venezuela in recent months has reached and passed its fortieth milestone. So rapid is the passing of time that this fact seems almost incredulous, and certainly it causes one to pause and consider the outstanding growth of the industry in that country, which now ranks second in the world.

The score adds up something like this:

- Productive area ..... 741,313 acres
- Reserves ..... 9,900,000,000 barrels
- Daily production (approx.) ..... 1,875,000 barrels
- Refining capacity ..... 497,000 bbl a day
- Oil and gas pipe lines ..... 2205 miles
- Investment in property $2,800,000,000

This certainly represents amazing progress for an industry that had a producing capacity of only 4000 barrels a day in 1921, seven years after the first commercial producer was brought in, and whose first refinery went on stream in 1917 with a capacity of 2000 barrels a day.

Success of such magnitude, we believe, can be traced to the enlightened oil policy that has permeated the thinking of Venezuela's officialdom since the beginning. It is thinking that recognizes the fact that success is based on freedom to explore and freedom to develop and produce once oil is found. A further step in this direction was taken last year when new acreage was opened up on the same basis.

Although changed somewhat over the years as a matter of standardization, Venezuelan oil legislation has proved entirely workable, and there has been a minimum of disagreements between government and operating companies.

Numerous changes in political structure have caused no radical changes in the attitude toward those who search for, produce, and refine oil. It has been an association of trust and cooperation by both parties.

That this pleasant relationship has been beneficial to Venezuela is obvious. That country's economy is dependent largely on the $400,000,000 annually received from petroleum operations. Standards of living have been improved, including health, housing, and education; and now oil revenue is being used to finance development of other industries that will make the nation less dependent on petroleum. It has also paid off for the operating companies.

In contrast, and without mentioning names, there also springs to mind oil policies pursued by some other nations, both past and present, with less than happy results both to themselves and to the companies who invest their capital and technical knowledge in developing an otherwise unmarketable resource.

— *Frank H. Love.*

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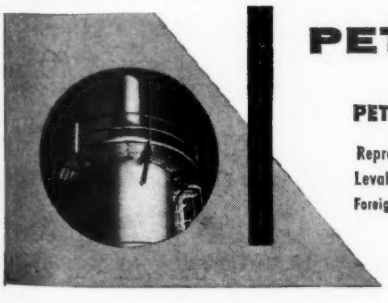

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HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Louisiana has cashed in again on its sale of offshore leases, the latest sale amounting to $21,173,551 in one day. Bonuses ran an average of $608 per acre, with a total of 34,777 acres being leased.

★ ★ ★

Asphalt demand, as reported by the U. S. Bureau of Mines, is on a constant upward trend. Figures, complete to November 30, 1954, show 6 per cent increase for 11 months of last year compared to 1953. Exports for last year were up 15 per cent. Domestic demand for November of 1954 rose 12 per cent over November, 1953. Imports of asphalt have also increased by as much as 75 per cent.

★ ★ ★

Government paper work, $4,000,000,000 of it yearly, employing some 750,000 employees, has been scored by a Hoover Commission task force. This group suggests that $40,000,000 might be saved annually on storage costs alone. (Read how red tape affects the gas industry on page A-47.)

★ ★ ★

Tulsa's International Petroleum Exposition has cancelled all plans made for a junior-sized show in 1957, and efforts are being concentrated on a 1959 show, coinciding with the centennial celebration of Drake's discovery well.

★ ★ ★

Shell Oil Company is moving into its new 14-story building in New Orleans, Louisiana. The $7,000,000 structure, providing 350,000 sq ft of floor space, will also house a bank, hotel, and other businesses.

★ ★ ★

Phillips Petroleum Company has entered the synthetic rubber business in Ravenna, Italy. Firm will supply engineering and technical aid for the $75,000,000 project by Ente Nazionale Idrocarburi, and will receive royalty payments for its share of work.

★ ★ ★

Atomic energy will be a help rather than a hindrance to the oil industry for at least 25 years, Dr. Robert E. Wilson, Standard Oil of Indiana, predicts. "For cars, trucks or buses the idea is fantastic," he adds, reassuring the industry that the new power has a long way to go before competing, much less replacing, coal and oil.

★ ★ ★

"Cut imports and you must cut the current depletion allowance," said Otis Ellis, of the National Oil Jobbers Council, before the House Ways and Means Committee. Reasoning is this: If crude oversupply is such to limit imports, there is no need for the 27.5 per cent exploration inducement.

★ ★ ★

Intra-state truck hauling of petroleum products is to be investigated by the Interstate Commerce Commission soon. Order came out of case involving Illinois truck movement of oil products entering the state via pipe line, thus making trucker part of interstate commerce.

★ ★ ★

Government will aid, not compete with, industry's petroleum and natural gas research, and will encourage projects that industry could not undertake by itself, Interior Secretary Douglas McKay has assured oilmen. Present activities by government are those prohibitive to private enterprise either because of cost, scarcity of materials, or considerations concerning national security.

★ ★ ★

The National Petroleum Council has named Jake L. Hamon, Dallas, to head a committee of 34 representatives of leading oil companies and associations to study oil imports. Vice-chairman will be Hines H. Baker, Humble Oil and Refining Company. The technical sub-committee, headed by Richard J. Gonzalez, also of Humble, has been named to carry on the group's work. Members of this group are listed on page E-29.

★ ★ ★

Texas has decided to up its March allowable to 2,902,000 bbl a day, in spite of pleas by purchasers to restrict runs to stills. State Railroad Commission based its increase on API committee findings, which reported refinery stocks running low.

Gasoline taxes are due for hikes in 21 states to finance highways, education, and bond issue needs. Tax bills range from an additional half-cent in Michigan to New York's bill raising the levy two to three cents per gallon. Indiana may try to outlaw the two-cent federal tax, not at all popular in any state. All of this could add up to complete stifling of the President Eisenhower extensive highway program for lack of funds.

★ ★ ★

Armed Services Petroleum Purchasing Agency called a meeting aimed at halting errors made on bids submitted to the government, sometimes serious enough to lose a contract. Suggestions and complaints on ASPPA procedures are being heard. Memos are being circulated to aid bidders for oil contracts.

★ ★ ★

New price scale for Alberta and Manitoba crudes have been established by Imperial Oil. While oil from Pembina's Cardium pool has been revalued 12 cents higher, sour crude prices fell off as much as 24 cents per barrel (Allerslie pool).

★ ★ ★

Single grade of 100-octane gasoline will be in use by 1960 or 1962, as all cars increase compression ratios. This prediction, made by Ford Motor Company's V. G. Raviolo, came with statement that low-priced cars would increase horsepower rating as much as 30 per cent in next three or four years.

★ ★ ★

Crude oil from Alberta will be moving to Washington state refineries at a rate of 75,000 bbl daily by the end of the year, Trans Mountain Oil Pipe Line Company officials have stated. Recently expanded Pacific Northwest refineries are creating a demand for about 250,000 bbl daily, expecting about 25 per cent of the increased amount coming from Canada.

★ ★ ★

More gas heaters were sold last year than oil heaters. Some 959,000 gas installations and 767,000 oil heating installations were added to the nation's space heating.

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Keynoting the trend toward large exploratory and capital outlays, Standard Oil of California will spend more than $300,000,000 during 1955, $25,000,000 above the 1954 level. In the four-year period since 1952, the company will have spent over $1,000,000,000 (including the 1955 amount). The money will be spread over work being done in Texas-Louisiana tidelands, Venezuela, Trinidad, Canada, and Hawaii.

★ ★ ★

Oak Ridge Institute of Nuclear Studies, a non-profit educational corporation of 32 southern universities, is conducting a course (4-week) in the techniques of using radioisotopes. Attending are 32 scientists and physicians from throughout the United States, including men representing the oil industry.

★ ★ ★

Armed Services Petroleum Purchasing Agency has revealed that it will buy 20 per cent more jet fuel in the fiscal year beginning July 1. This year's military consumption was about 70 million bbl. Demand for motor gasoline will decrease, in line with reduction in troop strength.

★ ★ ★

Industry leaders foresee shale oil products in competition with regular petroleum products, brought about by extensive research now carried on. Interest in the process has been renewed by Union of California's $5,000,000 entry into the field recently. Government development of the shale extraction method, entering its second decade, has been under fire by several interests for some time now.

★ ★ ★

A new bill has been presented "to make certain that the Natural Gas Act of 1938 is administered in the manner that it was intended," and exempting the sale of natural gas by independent producers from FPC control. Bill, offered by Texas Representative Frank Ikard, is one of several aimed at evading or revoking last year's Supreme Court ruling, and is "more in line with demands of the oil industry."

★ ★ ★

Esso Standard is financing scholarships for 145 high school and college teachers of driver education, to foster and encourage interest in better driving. Socony-Vacuum has announced it will contribute $324,-470 during the present school year for scholarships, fellowships, and grants in several fields — ranging from engineering, health, law, and industrial relations to aid for museums, libraries, and special scientific projects.

★ ★ ★

Two significant name changes have been made this month: Standard Oil Development Company has adopted the name of Esso Research and Engineering Company, with no changes in personnel, address, or purpose. Richmond Petroleum Company of California, a Standard of California subsidiary, will be known as the California Exploration Company, reflecting more accurately the activity and function of the organization. The company has been active in South America for several years.

★ ★ ★

Legal gestures toward complete elimination of oil men from the Montana Oil and Gas Conservation Commission, may bring the operators in that state to grips with a hostile legislature. Oil development in Montana hinges on this action, combined with attitude of the state government toward leasing of state lands. Obstacles thrown up to oil men seeking to lease Montana lands have almost halted drilling and exploration.

★ ★ ★

Use of coal and gas to feed the nation's electric utilities marked up a record high in 1954, government records show. Coal consumption was up 2.2 per cent and gas 12.5 per cent over 1953. Fuel oil use was off 18.8 per cent, burning nearly 67,000,000 bbl. Gas transformed to electrical power measured a staggering 1,163,526,151,000 cu ft.

★ ★ ★

Oil can and will compete effectively with natural gas on the West Coast, provided that industrial consumers are educated to use heavier, cheaper fuel oils than now in use, Standard of California President T. S. Petersen has emphasized. Gas competition into the California residual fuel market is in the offing with the completion of the pipeline from the San Juan Basin.

Governor Gary of Oklahoma has lashed out against states not prorating oil production. He contends that his state could produce 550,000 bbl daily all the time if other states now without controls (Colorado and Wyoming) were prorated, and if foreign imports do not increase. Oklahoma has been forced to cut its own allowable to satisfy crude purchasers and overloaded refiners.

★ ★ ★

Long needed state legislation to aid offshore drilling activity in California is well under way. Four new bills have been introduced and stand good chance of approval. Tidelands activity has long been stymied by bans on platform and barge drilling on submerged state lands, drainage permits and other barriers.

★ ★ ★

Natural gas service to thousands of new users in seven states has been assured late this year or early in 1956 with the completion of Pacific Northwest Pipe Line Corporation's new 1700-mile line from New Mexico to Washington. FPC has given final approval for the $163,000,000 project.

★ ★ ★

Walter S. Hallanan, chairman of the National Petroleum Council and president of Plymouth Oil Company will receive Texas Independent Producers and Royalty Owners Association annual recognition award. Honor will be paid him at the organization's convention late this month for his "symbolism of free competitive enterprise spirit."

★ ★ ★

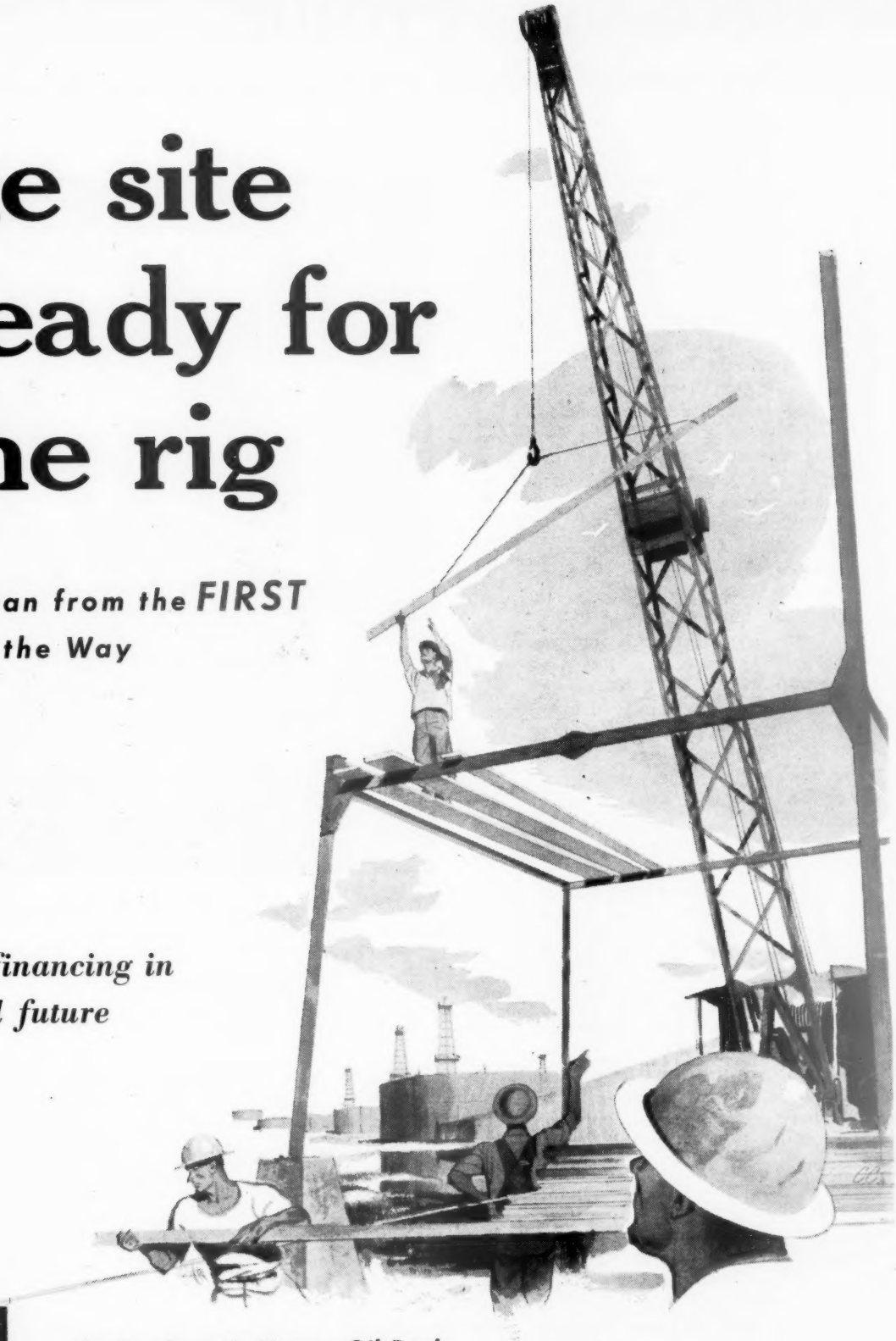
Increased oil imports and reduced demand for domestic crude is predicted for the quarter ending April 30. Word comes from the Independent Petroleum Association of America, citing that February supply levels would outrun requirements, while foreign crude allotments would increase 190,000 bbl per day.

★ ★ ★

Wyoming has been added to list of members of the Interstate Oil Compact Commission, bringing the total to 29 participating states. State bill was approved by the legislature and signed by Milward Simpson, governor of Wyoming, the sixth-ranking oil producing state.

the site is ready for the rig

and a Loan from the FIRST Cleared the Way



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Petroleum Profile

A young newspaper man walked out of the Ardmore Trust Company of Ardmore, Oklahoma, one day in 1912, in search of someone to go on his note for $250. He wanted to get in on an oil deal.

The first person who agreed to sign the note for Roy M. Johnson was C. M. Joiner, who came to be better known as "Dad" Joiner, the discoverer of the great East Texas field.

In 1913, oil was found on the west edge of Carter County. It was the Healdton field, which has produced a quarter of a billion barrels of oil and marked the beginning of the great development that still goes on in the Ardmore Basin. Editor Johnson, who described his newspaper as a "weak weekly," had joined the ranks of the oil industry. Ever since that time he has been one of those men—the wildcatters who are the life blood of the oil business. He risks capital at great odds on a mere possibility of finding oil. If he hits, the sure thing is sold so the money can be used on another try.

Roy Johnson was 31 when the strike at Healdton was made. He was born in Wisconsin, son of a Seventh-Day Adventist minister. His parents went to Nebraska when he was a baby and, in 1899, he was graduated from Union College at Lincoln. Following the Adventist practice that each boy should learn a trade, Roy had taken up printing. He went to work in Battle Creek, Michigan, as a printer for five cents an hour.

It was at this time that he got his first taste of the oil business and it should have discouraged him forever. He put all his savings into the Apollo Oil Company, an Iowa concern that was drilling a well near Beaumont, Texas. It was a dry hole.

But the location brought him into closer contact with a reporter from the *Beaumont Enterprise* and Roy was offered a handsome salary of $22.50 a week to come down to Texas. He went and stayed four years—long enough to get a stake to start the weekly newspaper at Ardmore. This paper he mortgaged for $2,000 at 12 per cent which he used to block up leases at Healdton.

Ardmore sparkled with oil adventurers in those days—most of them young and from many other businesses—lawyers, bankers, merchants, newspapermen. There was Wirt Franklin, P. C. Dings, Wm. G. Skelly, Jake Hamon, Sr., John Ringling, Frank Merrick, Dad Joiner, and dozens of others, many of whom went on to high places in the oil industry.

Roy M. Johnson

Wildcatter

Roy Johnson in the early days lived in the home of C. O. Bunn. His son, John R. Bunn, became a geologist and he and Johnson were fast friends and sometimes partners. A few years ago on Bunn's recommendation, they picked up 70,000 acres in the Uinta Basin of Colorado and Utah, on which gas was found in the Mesa Verde, and on which Phillips Petroleum Company found oil in the Morrison. This has been the latest in a long series of ventures for Johnson.

If you think, because Roy Johnson has made several fortunes and is 73 years old, that he is ready to retire, you are far wrong. His office is a hub of activity. He keeps close tab on all his business dealings; a lot of it sticks in his memory, and he almost never needs to refer to his files.

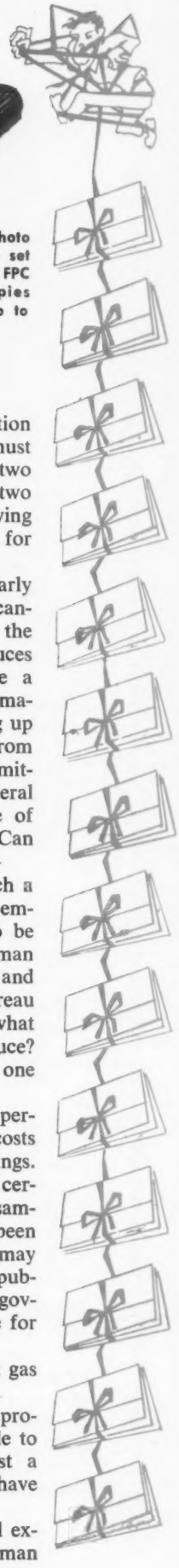
His son, Otey, a geologist, helps him some in his business but Dr. Otey G. Johnson is also a Doctor of Medicine, and, right now, is building for Ardmore the most beautiful clinic in the Midwest. Roy's daughter, June, married Martin M. Cassity, and provided four handsome grandsons to round out the family. He has the devoted attention, too, of charming Mrs. Johnson, a sister of Texas' famous writer of Civil War stories—John Thomason, Jr.

Johnson has served his country and his state as a public officer. Among other offices, he was appointed to the first State Highway Commission in 1924. Governor Murray, in 1954, named him to the Oklahoma Turnpike Commission.

Roy's religion casts a warm glow over his personality. His strict adherence to Adventist precepts (he hasn't eaten meat since he was seven years old) does not make him stern; instead, he is friendly and understanding and highly popular. It is his kind that keeps the oil industry going forward and guarantees that it never will be dull.

Red Tape Can Choke Interstate Gas Sales

Photo of one set of papers for FPC filing — 15 copies just like it must go to Washington, D. C.



Ernestine Adams*

ONCE upon a time if you were lucky enough to hit gas near an interstate pipe line all you had to do was to sign a contract with the transmission company and hook on to a gathering line and you were in business.

When the Supreme Court decided June 7, 1954, that independent gas producers selling in interstate commerce came under control of the Federal Power Commission this simple, direct way of selling gas went out the window.

In order to be "controlled" an independent producer must tell the FPC all. He must tell pages and pages and to be on the safe side, he better get a lawyer to tell it as legally as possible.

The lawyer had better know FPC rules and regulations till he can follow in the dark, too, because every time he takes a step there are two or three paths ahead.

Before you turn on the gas, you have to get a Certificate of Public Convenience and Necessity. This sounds as if the Certificate may give you a franchise for a protected business like a public utility but it doesn't. You have to prove in detail that selling gas to an interstate transmission line is what the public wants and needs.

Of course, the transmission company already has a Certificate of Public Convenience and Necessity or it couldn't buy the gas anyway but don't let common sense creep in here. Operation Red Tape has just begun.

In applying for this certificate to sell your gas production the form and contents are prescribed in some detail in Order 174-B (Order 174 and 174-A have already fallen by the wayside). You and your lawyer figure the answers out. It will probably run 30 to 40 pages including the contract and a property map. After you get the original together you need (usually) 14 conformed copies for the FPC besides those for your own office. Copies must also be served on state regulatory commissions and interested parties.

The photo on this page is an operator's copy of one application. Fifteen just like it were sent to the FPC in Washington, D. C. Photostatting cost $84. One file weighs about three pounds so postage for 15 copies runs into money. Cost of legal consultant and office employees went considerably beyond these other expenses.

This man's share of the lease covered by the file is .057988 or just over 1/17 of the lease interest. The other six owners in the lease had to supply the same volume of papers.

One large company in the Southwest assigned its controller's department the chore of making applications after the FPC regulations were applied to independent producers. It took 16,000 manhours to compile a mass of documents that reached 25 ft high to complete applications for certificates to sell the gas the company had been selling for years.

Another company estimates each one of its FPC filings averages about 500 pages.

Twenty-five employees in still another company devote full time to FPC work; the amount of manhours put in by other employees on a part-time basis cannot be estimated. This company has prepared 257,600 pages for the FPC on rate schedules, applications for certificates, rate changes, withdrawals, and terminations. Just the correspondence and inter-office memos concerned with FPC filings amounted to more than a set of encyclopedias—about 8000 pages.

At the same time the application for the certificate goes in, you must submit to the Secretary of FPC two copies of the sales contract and two copies of a sample billing showing how much gas you expect to sell for how much money.

Here again is a regulation clearly intended for utility service—it cannot rationally be fitted over the heterogeneous group that produces natural gas. Can you imagine a wholesaler of any other salable material in a free economy holding up sales until he had permission from the government to sell and submitting his sales contracts to a Federal bureau along with an estimate of how much he hoped to make? Can you?

You might guess at what such a regulation would do to Federal employment if permission had to be given in each case before a man could sell a product for resale; and the cost of operating such a bureau would run into billions. So what would all this regulation produce? Just what it is producing with one isolated industry—red tape.

The red tape required to get permission to sell gas sometimes costs more than the sale of the gas brings.

When the application for a certificate and the contracts and sample billing are all in and have been processed by the FPC staff (this may take many months) a notice is published in the Federal Register, a government paper, setting the date for a hearing.

You're not eager to sell that gas right away, are you?

Usually you won't have any protest and if the FPC is agreeable to the gas sales you can request a shortened procedure and don't have to be at the hearing.

This hearing is before a trial examiner appointed by the Chairman

*Management Editor.

of the FPC. A lawyer for the Commission presents your case and says it's all right with the FPC staff.

So the certificate is issued saying you can sell gas, you lucky operator, and you can use your own facilities. This last is heaping insult on injury. Not only do you have to get permission to sell gas because it crosses the state line but you have to get permission to use your own facilities in your own state because the gas touches them.

It's like getting permission from Washington to use a truck to haul wheat to the mill because later the flour will be sold across the state line.

Your certificate isn't any good, don't forget, unless you file a formal acceptance within 30 days. You can see what was meant by saying you need a lawyer.

Now you can turn the gas into the interstate line.

This procedure is the easy route to selling gas to big transmission companies.

If anybody protests the filing you get the full treatment. You must be represented at the hearing and the trial examiner writes his opinion about whether you can sell gas as your contract calls for.

If you or the party who protested isn't satisfied, an appeal from his decision can be made to the Commission itself.

If you can't accept the FPC's decision, you appeal to the Circuit Court, and from there you can go to the Supreme Court, if you wish.

This can take years of time, and tons of paper and sacks of money and you aren't selling gas in the meantime, you know. This might give you the idea of getting out of the gas-producing business.

Even if you get by on the shortened procedure, you aren't through. Most contracts call for price increases during the 20 to 25 years they are in force. But the price can't be changed now without FPC approval. So you file an application for price increases. The Commission may allow these to go into effect or, if it desires, it may hold a hearing at which you have to prove that the new rate is reasonable.

All this time you get no increase in price paid for gas you sell no matter what the contract says. The contract is set aside by bureau regulation. The rate is said to be suspended. You take the old rate and like it and don't stop selling gas or you'll have a more serious hearing on your hands.

You could have a fine up to $5000 and a jail term up to two years for any violation of these regulations and you might have to pay $500 a day for each and every day you do not comply. Nobody speaks of these threats at the moment but they are clearly visible and can be used.

Now some contracts call for .002 cents a 1000 cu ft increase each year. If you're selling one billion cubic feet of gas a year, that is an increase of $2000 for the year's production. Your hearing for a rate increase can cost you that and more.

When the FPC took over control of independent producers of gas in interstate commerce, a number of contracts stated that the deal was off if the seller came under Federal jurisdiction. But the producer soon learned it was harder to stop selling than to begin to sell under the Commission's regulations.

* * *

Paper work for FPC regulations sometimes costs more than gross returns from natural gas production — As usual the consumer will pay.

* * *

In one such case each one of 15 parties had to file 22 separate documents in an effort to stop supplying gas to an interstate line. Each party had to have 35 sets of these documents—20 sets for the FPC and 15 for others interested in the project. This amounts to some 11,550 documents—not pages; instruments, as the attorneys say.

In this instance one company has a $32 a month return from the property. No decision has been reached in the case and it could go on for years — hearings, postponed hearings, appeals to the Commission, and appeals to the courts.

Do you think all this sounds like red tape might be pressing down mighty hard on interstate gas sales? You're right. It has already choked off some gas production at the state line. But don't forget, this is the simplified procedure — so simple, in fact, it may be illegal. If natural gas producers had to follow the same procedure as that set up by the FPC for transmission companies, it would call for many times this much red tape. There is a question whether the Commission can set up two types of "natural gas" companies — producers on the one hand and pipe line companies on the other—when the law provides for only one class of business and everybody covered to be treated equal.

Of course, the law doesn't fit because it is clearly meant for transmission companies, which are to be managed as public utilities because they have no direct competition. The companies are big; the number of companies and projects are limited.

Congress evidently thought transmission companies that also had gas reserves might try to supply their own lines and thus set a non-competitive price on gas, so it applied the regulatory provisions "to the sale in interstate commerce of natural gas for resale for ultimate public consumption" but the Natural Gas Act of 1938 also states clearly that these regulations don't apply "to the production or gathering of natural gas"—in other words, to the "independent" producer.

The majority of the Supreme Court, however, could see no difference in regulation of transmission companies' natural gas supplies and those of other companies that sell to transmission companies.

The attempt of the FPC to apply to one business regulations derived from a law enacted for a completely different kind of business adds chaos to confusion. The Commission tried to improve matters by simplifying procedure but uncertainties show through pages of instructions.

Red tape has tied up the Commission as well as the independent producers. Some 10,000 filings have been submitted since the Supreme Court decision last June and the FPC is said to be about 3 years behind on hearings.

Who pays for the tightening red tape of delay, confusion, "public inconvenience and unnecessity"?

At first glance it looks like the gas producer but he only pays in bewilderment and anguish and frustration. Red tape is a cost of service and the Circuit Court of Appeals has recently pointed out that a "rate based upon the exclusion from the cost of service, no matter for what reason . . . may . . . not stand." In other words, expenses shall not cut into reasonable profit.

So who pays for the red tape? The consumer, of course.

Puerto La Cruz manifold in Eastern Venezuela. —*Creole Petroleum Photo.*

P 122.

One South American nation has taken full advantage of its resources and has attracted foreign capital to build a great nation whose riches are used for its people's advancement.

VENEZUELA — *Opportunist of the West*

by V. S. Swaminathan, experienced oil writer, this exclusive article shows why Venezuela's 40 years of oil development has given it a thriving industry and a prosperous economy.

FIRST OF TWO PARTS

JULY 31, 1954, was the fortieth anniversary of the completion of the first oil well in Mene Grande field, which was the first commercial producer in Venezuela, brought in by Caribbean Petroleum Company, forerunner of Compania Shell de Venezuela, in 1914. To mark the occasion a commemorative plaque was unveiled at the well site.

The importance for the oil industry and for Venezuela of the discovery of MG-1, is now a matter of history. Shell's operations in Venezuela alone had developed from MG-1's original 250 bbl a day to the present total of all its fields of approximately 600,000 bbl a day. Although long since closed in, the MG-1, on being cleansed in preparation for the anniversary celebrations, had proved itself a faithful friend by producing about 150 bbl a day.

Oil was known to exist in Venezuela since the time the Spanish conquistadores caulked their galleons with asphalt scraped out of oil seeps on the shores of Lake Maracaibo. Nineteen years after the Drake well came in at Titusville, Pennsylvania, a small indigenous enterprise, the first oil company in Venezuela, drilled some wells in the Andean foothills and out of the crude output of 15 bbl a day, supplied the immediate environs with illuminating kerosine. This minor operation continued until 1938.

Although the first commercial production was founded on the shores of Lake Maracaibo in 1914, the Venezuelan petroleum industry really got under way in 1921 when output averaged a mere 4000 bbl a day in round figures. Then the country was predominantly agricultural, its economy based on corn, cotton, coffee and cocoa beans. The remarkable progress registered by the industry since 1921 is brought out by the data below, which also gives the national treasury income:

Year	Oil production	National treasury income	
		Million bolivars	Million dollars
1921.....	4,145 b/d	82	13
1931.....	321,000 b/d	210	36
1941.....	625,000 b/d	325	95
1951.....	1,700,000 b/d	2112	630

Thus in 1951 oil production was 410 times and national treasury income 26 times that in 1921 and population doubled during this same period.

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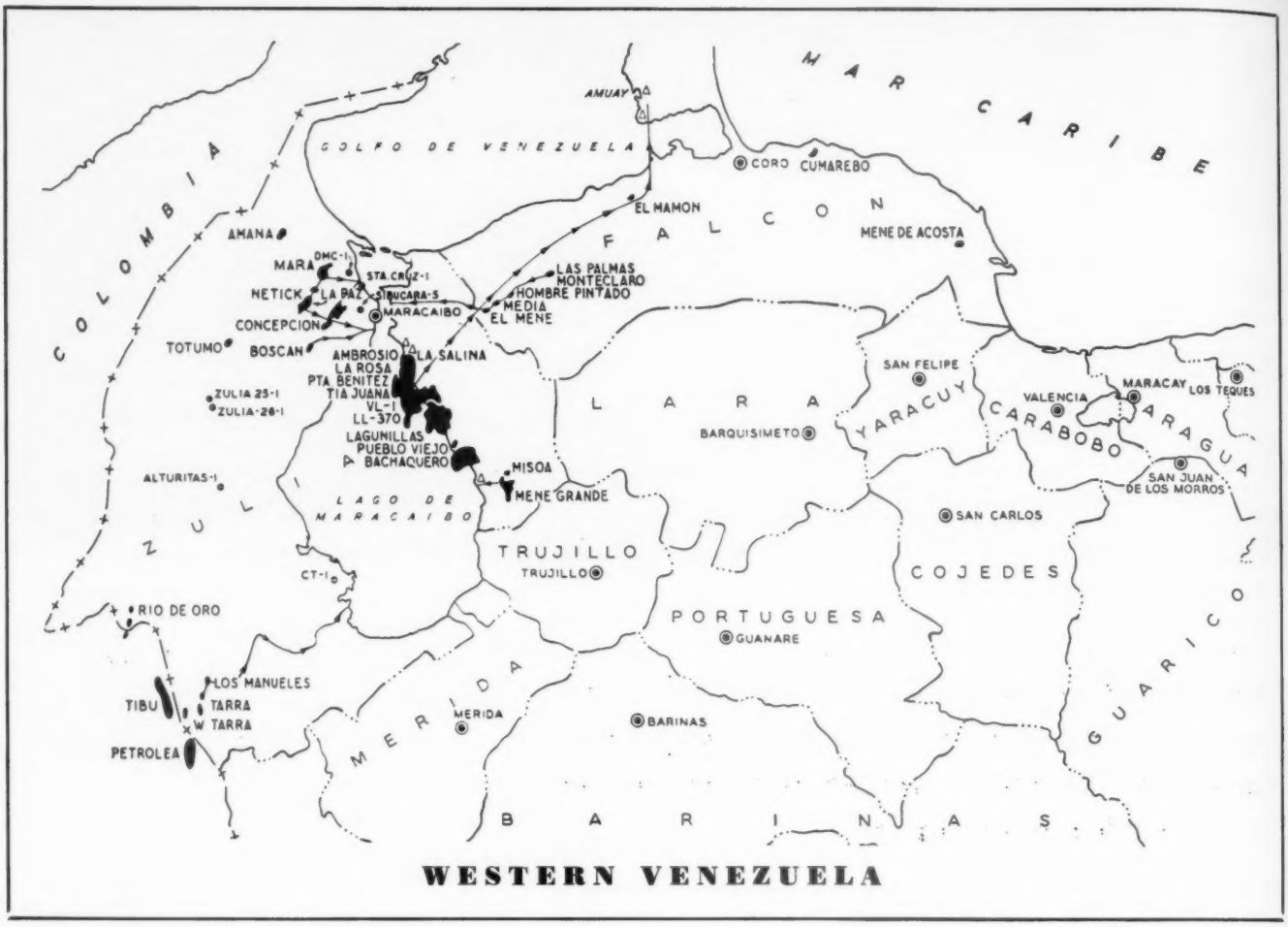


WESTERN VENEZUELA

WESTERN VENEZUELA

Venezuelan oil industry is second in importance only to that in the United States. It represents the world's largest oil exporting country and is a classic example of the benefits of private, competitive enterprise. An enlightened petroleum policy has been followed by the republic without any radical change by successive governments. Of late, the state's waxing oil revenue has been fertilizing a variety of projects designed to improve the standard of living, i.e., schools, housing, public works, sanitation, and communication facilities, and also financing the development of other productive assets that will eventually diminish the nation's present heavy dependence on petroleum.

Both capital and technical "know-how" for the development of Venezuela's now thriving oil industry have of necessity been foreign. British and Dutch companies were pioneers in the search for the Republic's oil. They were followed soon, and aggressively, by several large American corporations. For many years considerably more than half, and of late, nearly 90 per cent of the country's petroleum production has come from the operations of the subsidiaries and affiliates of the three great international oil companies—Jersey Standard (controlling stockholder in Creole Petroleum, now the leading producer), the Royal Dutch-Shell Group, and Gulf Oil Corporation (Mene Grande Oil Company). Shell is represented in Venezuela by three units: Shell Caribbean Petroleum Company Ltd., Colon Development Company Ltd., Venezuelan Oil Concessions Ltd.

Others, national and foreign, are also operating successfully in Venezuela. Here is a small list of them: Socony-Vacuum Oil Company (Venezuela), Texas Petroleum Company, Venezuelan Atlantic Refining Company, S.A. Petrolera Mercedes, Sinclair Oil and Refining Company, Pantepec Oil Company, Richmond Exploration Company, Phillips Petroleum Company, British Controlled Oilfields Ltd., and Gusare.

The highlands to the west and north of Venezuela, though occupying a relatively small area, contain the greatest proportion of the population. The lowlands of Lake Maracaibo are handicapped by a severe tropical climate, tempered somewhat by the cooling trade winds. Here are found the major oil fields of western Venezuela. Through the center runs the llanos, or plains, covering about a third of the total area drained by the Orinoco and its tributaries.

In 1917 Venezuelan Oil Concessions Ltd., another Shell subsidiary, discovered La Rosa field. In 1922, when one of its wells started blowing wild at an estimated 10,000 bbl a day, it became world famous and gave wide publicity to the tremendous productive possibilities of the country. An oil boom soon developed in the Lake Maracaibo region, inaugurating an era of intensive and widespread prospecting in both Western and Eastern Venezuela.

Maracaibo Basin. The Maracaibo Basin has an area of approximately 24,000 square miles, 5000 of which are covered by the waters of Lake Maracaibo. It lies in a V-shaped depression formed by the bifurcation of the Cordillera Oriental of Colombia into the northeast trending Venezuelan Andes on the southeast side, and the Perija mountain range on the west. Since drilling began in the Mene Grande area in 1914, eight major fields have been developed in this basin.

Bolivar Coastal Field. The BCF stretches over an area straddling the east shore of Lake Maracaibo for a length of 43 miles from northwest to southeast, the width varying markedly, and reaching a maximum of 10 miles in the central part. Shell's discovery

well in this area was completed in 1917 as a small producer from the Santa Barbara sand of the La Rosa formation. It was not until 5 years later when Shell well R-2 blew out, making an estimated 100,000 bbl of heavy oil per day, that the real stimulus was provided for the development of this prolific oil-bearing area. After more than 30 years of development the limits of the productive area are not yet fully delineated.

Venezuelan Oil holds all the land concessions in the area, and subsequently Shell extended its original holdings by acquiring several large lake concessions, in one of which the exploratory well VL-1 resulted in a new pool discovery. Mene Grande holds several concessions in the so-called "kilometer strip," paralleling the shore line, while Creole's concessions lie entirely within the lake.

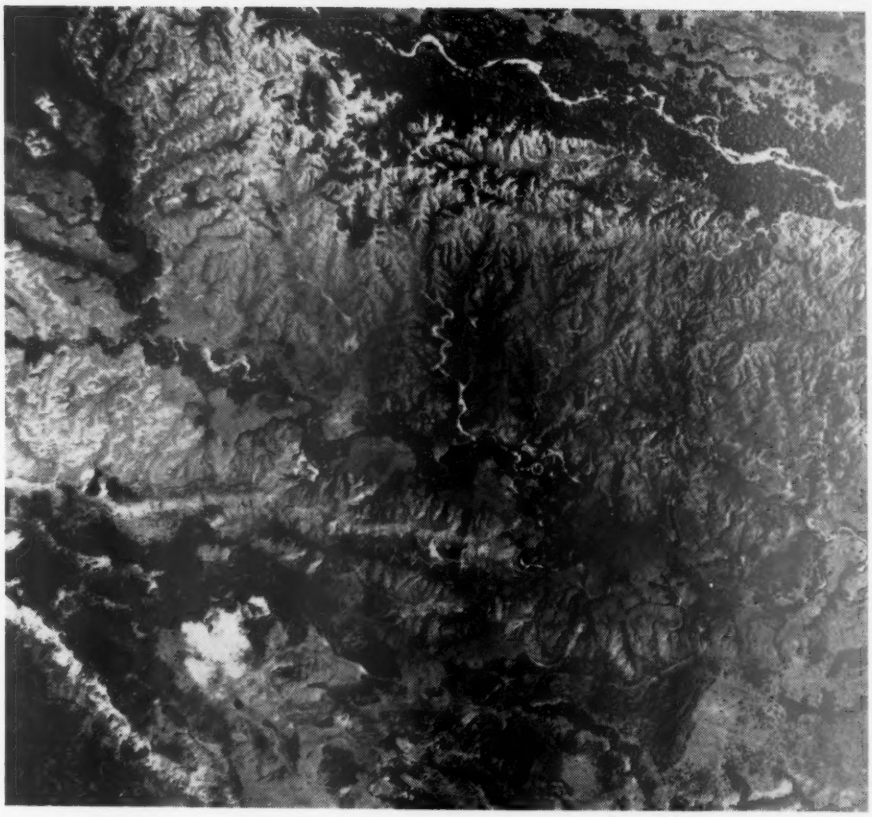
The BCF is on the northeast flank of the Maracaibo Basin. The regional structure is monoclinal, the dip being gently to the southwest toward the center of the basin. Within the productive area the drill has penetrated sediments ranging in age from Recent to Cretaceous. Shell VL-1 was the first well to reach Cretaceous beds, but Creole's LL-637 was the first to penetrate completely the stratigraphic sequence by reaching basement at 13,813 ft.

The two most pronounced of several uncomformities within the desimentary section of the BCF occur at the tops of the Palescene and Eocene. At one place or another within the productive area—the Lagunillas, La Rosa, and Icotea—Eocene formations have been found commercially productive. By far the largest volume of oil to date has come from the Lagunillas and La Rosa sands, with production from Eocene sandstone steadily increasing in recent years. Eocene production did not, however, receive serious consideration until 8 years ago.

Cretaceous production is also a future possibility despite the salt water flow from the limestone at 12,106 ft in Shell VL-1 and the unproductive sections found in Creole LL-637 and Shell LB-273.

Oil and gas accumulations in post-Eocene sediments are mainly confined to stratigraphic traps, while in the underlying Eocene beds they are largely controlled by truncation, overlap, and faults. The oil varies greatly in gravity from 11 to 34 API; is of mixed asphaltic base with a wide range of characteristics and is segregated into several streams.

In 1953 the 1950 producing wells drilled in Lake Maracaibo yielded approximately 645,000 bbl a day. With over 3200 wells on land of the same district these accounted for close to 900,000 bbl a day, or 1/14th of world production.



Aerial photographic mapping is of inestimable value to the gelolgist working in Venezuela. It provides a reliable topographic guide. *—Shell Photo.*

Mara Field. Mara is one of the important oil fields of Venezuela, and ranks second only to La Paz as a Cretaceous limestone producer. Situated 22 miles northwest of the city of Maracaibo and 6 miles northeast of La Paz field, it was discovered by Caribbean Petroleum Company, a Shell subsidiary, in 1945. Mara is an excellent example of unit development carried on by Mene Grande, Texas, Shell, and Creole. Shell is operating for Texas and Creole, while Mene Grande does its own operating.

The field is folded and faulted anticlinial structure, approximately 12 miles long and 5 miles wide, with the axis trending northeast southwest parallel to the Perija mountain chain some 20 miles to the west. Its structural picture was built up with the aid of seismic investigation. The productive section of limestone may comprise any part of the 1800 ft of the structure's normal thickness. The matrix of limestone is dense, having a low porosity and a very low permeability (less than 0.1 millidarcys). Its outstanding feature from a productive angle is the existence of extensive fissure systems.

Cumarebo Field. This field, discovered in 1931, is an elongated anticlinal dome striking in a northeast direction on the northwest dipping flank of the Ricoa uplift. Its structure was first delineated by surface geology, and the wildcat well which discovered the field CU-1, a proposed 5000 ft test drilled on the crest of the anticline, encountered the top of Sand 8 (Caujaro formation, Mid-Miocene) at 610 ft. It was completed with an initial potential of 700 bbl a day at a depth of 627 ft.

The dome is severely faulted, there being three systems of faults—regional, secondary, and strike. Of these the large regional northwest striking faults dipping 45° to the northeast are of major importance in that they form barriers and blocks controlling the accumulation of oil. Production is from fine grained, fairly well sorted 10 to 12-ft sands of Canjaro and 15-ft Mosquito formations. The depth of producing horizons varies widely from 405 ft (sand 6 in CU-67) to 2635 ft (sand 16 in CU-21).

EASTERN VENEZUELA

Quiriquire Field. The first field of major importance in eastern Venezuela was Quiriquire, discovered by Creole's predecessor, Standard of Venezuela in 1928. Its discovery followed 7 years devoted to exploration work, opening up of the jungle and transportation of heavy equipment to inaccessible places, at a cost of $45,000,000. The Quiri-

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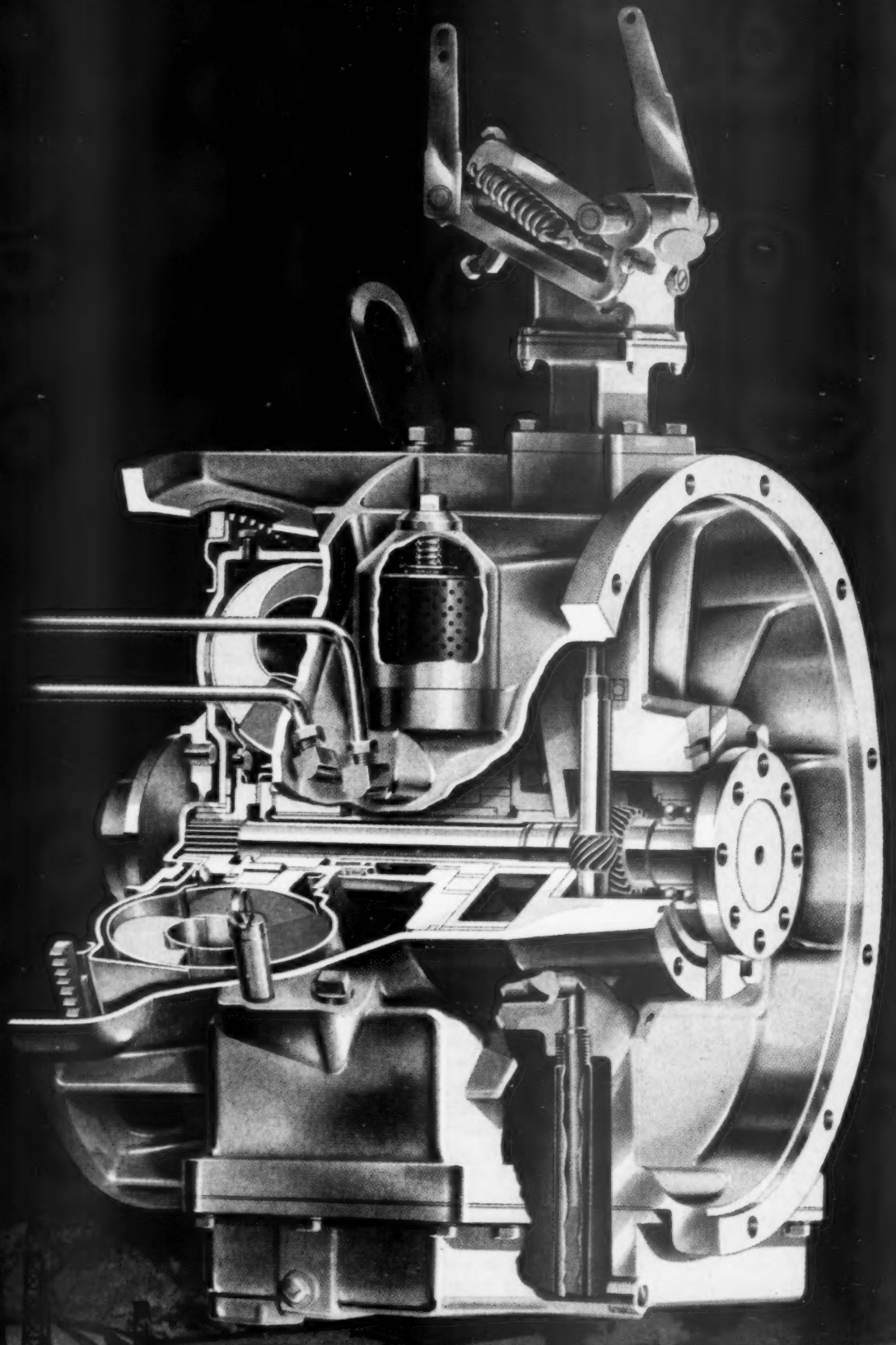
OUTPUT UP-COSTS DOWN



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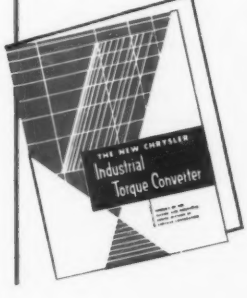

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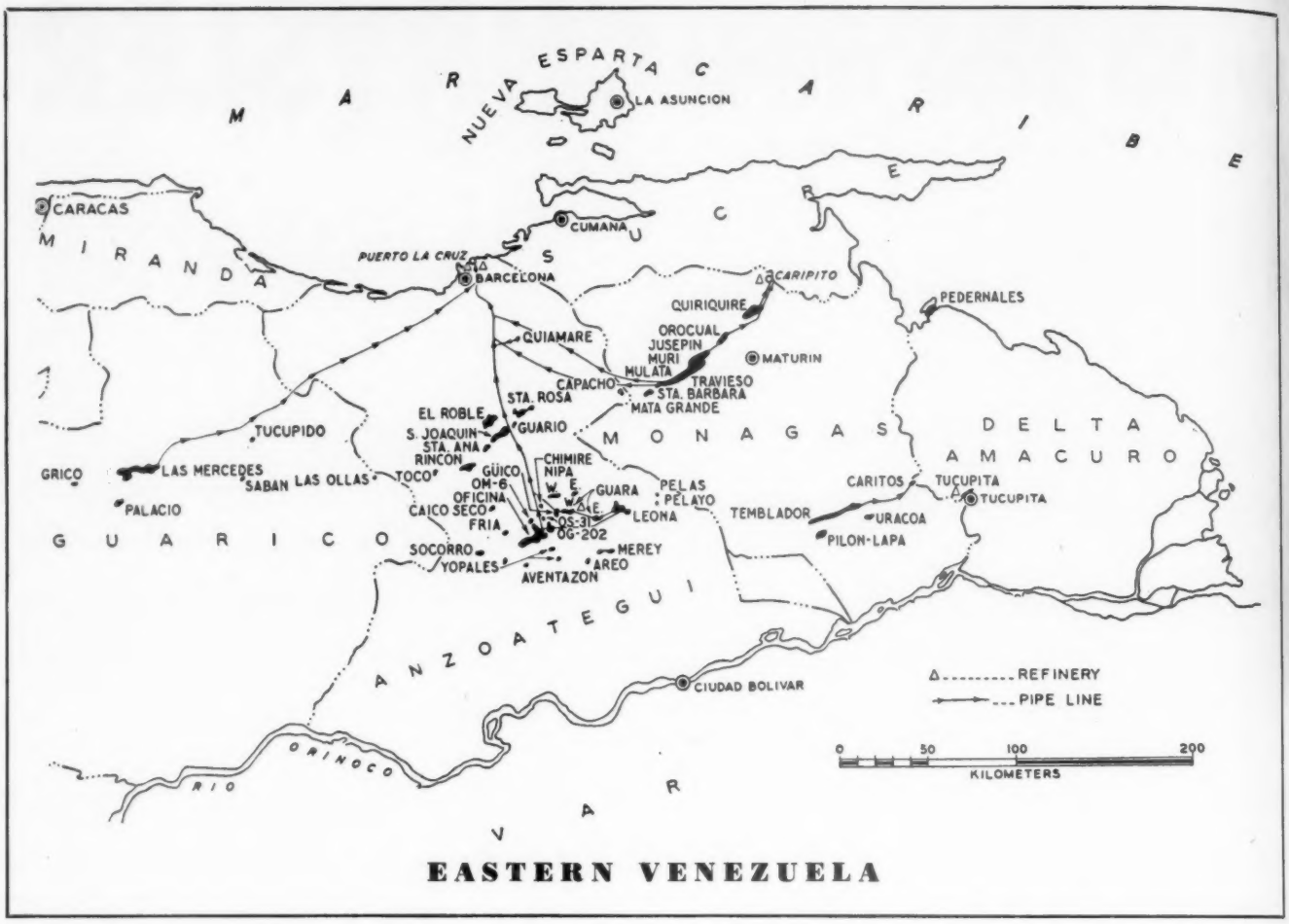


EASTERN VENEZUELA

quire discovery well, Moneb-1, was brought in as a flowing producer.

The Pliocene Quiriquire formation, the field's main reservoir, is an interfingered, overlapping alluvial fan series, continental in origin and deposited unconformably on truncated beds ranging in age from Cretaceous to Miocene. Structurally it is a northeast trending monocline dipping southeast from 4° to 10°. Oil accumulation is an irregular oval in shape, 4 by 8 miles, with the maximum overall thickness of net oil sand in the central part of the field 732 ft and a mean average of 233 ft per well. Productive limits are yet to be determined for the eastern half of the field.

Quiriquire oil varies from 12 to 28 gravity in productive section and the crude is relatively heavy with a sulphur content of 1.18 per cent. The normal naphtha cuts have an octane rating of 77 with a fill of 5 per cent at 212°. A small light naphtha cut can be utilized for aviation gasoline production and suitable tractor fuel can be produced. Gas oil from this crude has a low diesel index. The crude is unsatisfactory for the production of penetration asphalts. The oil is excellent for the production of high octane gasoline and yields a satisfactory heavy diesel oil of relatively low sulphur content, as well as bunker fuels of superior quality.

Jusepin. Productive area of Greater Jusepin may be considered one field trending 60° northeast for 27 miles and attaining a maximum width of 4½ miles. Output from the Miocene La Pica formation was discovered along northern rim of east Venezuelan Basin. Jusepin No. 1 was completed by Creole in 1938. As its development progressed other companies holding concessions to the west along the trend became interested and initiated development. Specific gravity of the crude is 22 to 36, the average being 31. It exhibits moderate sulphur content and is especially suited to production of motor fuel of average quality, various grades of gas oils, diesel oils and bunker fuels.

Pedernales Field. This field on the Gulf of Paria opposite the southwest corner of Trinidad. Its structural interpretation portrays an anticlinal high, complicated by faulting, trending from Trinidad through Pedernales. From discovery of the field to the end of 1938 when drilling activity terminated, 13 oil wells and one dry hole were drilled in the immediate area of the discovery well.

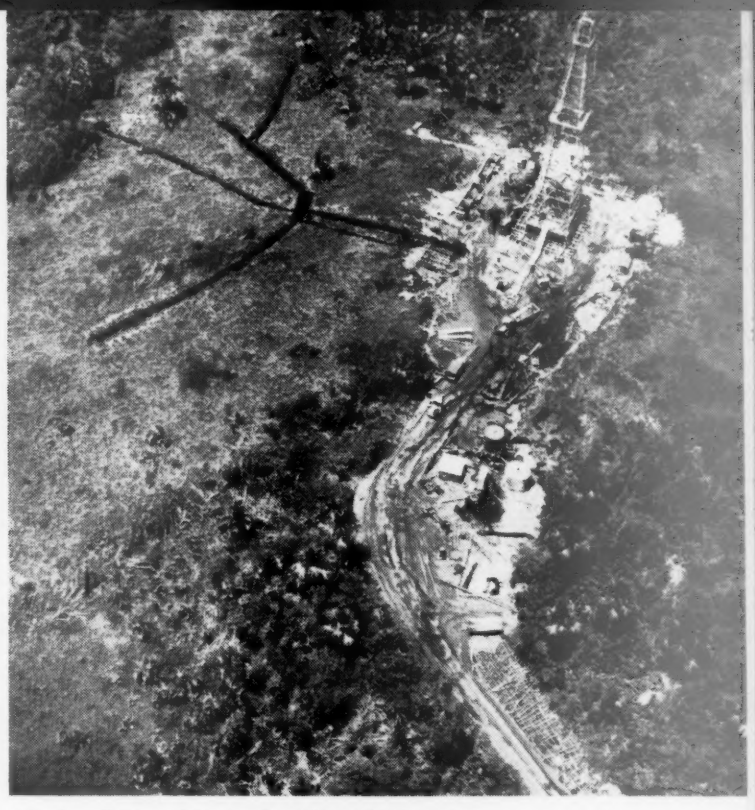
Anaco Area. Since the completion of the discovery well Santa Ana-1 (AM-1) in 1937, six fields have been established in the Anaco area in the central part of Anzoategui state. The oils, of 33-47 gravity, are typically waxy. A large percentage of reserves is composed of 47 to 60 gravity condensates. The fields extend over a distance of 40 miles in a northeast direction with a maximum width of 9 miles.

Location of Santa Ana-1 was based on surface and aerial geological work carried out in 1943, which outlined the Santa Ana and San Joaquin domes. Further discoveries were due to reflection seismograph and subsurface geological work. Production is from sands of the Oficina formation from 6000 to 10,000 ft.

Greater Oficina Areas. This region in the south-central part of Anzoategui and on the southern stable foreland area of the Matwin Basin. The discovery well was completed by Mene Grande in 1937. The Greater Oficina area covers approximately 1390 square miles, and extends 56 to 26 miles in east-west and north-south directions. The larger part of the concession is owned by Mene Grande, or jointly by Creole and Mene Grande.

Initial wildcat locations leading to the discovery of oil fields were based largely on refraction seismograph work. Other exploration techniques included reflection seismograph, tarsion balance,

Exploratory well in Pedernales field.



Another Eastern Venezuela wildcat in Guanoco.

magnetometer, and gravimeter survey, completed by subsurface geological work and structure drilling. Produc- comes from sand units of the Oficina formation, and oil accumulation is primarily controlled by faulting.

Turning to recent developments the Greater Oficina complex, a big concentration of oil fields in the southern half of Anzoategui in Eastern Venezuela, has been extended eastward almost to the border of Monagas State by the addition of two new fields.

Venezuelan Atlantic's Junta-2, 15 miles east of Mene Grande's Leona field, was a successful completion, but was followed up by a dry hole only 500 yards southwest. Junta-4, 900 yd southeast, tested one sand for oil and one for gas, and still has two prospects, which have given oil shows but await conclusive testing. Atlantic thus appears assured of a field. East from Junta-4 and west from Leona field Mene Grande made a satisfactory dual-zone completion of wildcat Adobe-1. Also, the future of the far east corner of Anzoategui appears reasonably well assured.

Northeast from Oficina, the Mara area is growing with The Texas Company (credited with the discovery), and Mene Grande and Socony developing separate sizable fields.

Northwest from Greater Oficina, nearly 15 miles southwest from the town of Aragna de Barcelona, a new oil province may be in the making for Anzoategui State. Mene Grande's Casca-1, rank wildcat 20 miles from any producer underwent tests for several weeks since it was bottomed at around 10,700 ft. It was completed as an oil well, and Mene was preparing to spud Casca-2, some 2000 yd to the southwest. Shell has plans for North Anzoategui with a series of six tests. These are to test shallow shows noted during the testing of the 12,000-ft VC-1 abandoned as a dry hole nearly 4 years ago. Then this company drilled two such deep tests, both dry and pulled out of Anzoategui $40 million in the red for surface exploration, construction, and drilling. Shell also plans a 9000-ft wildcat at a point between the town of Onoto and Menegs Casca-1 well and a series of 6000-ft tests in the general area.

Temblador. Situated in the south-central part of the State of Monogas, this area has three separate fields—Temblador, Pilon and Uracoa. Temblador field proper extends over a distance of about 25 miles in a generally east-west direction, has a maximum width of two miles, and is operated by Creole. Wells drilled on former Lago Petroleum concessions are named Temblador (TT and TY) wells, those on Mene Grande concessions Hato (TH) wells and those on the original parcel selection of former Pantepec concessions (TR and TRN) wells. Wells drilled on former National Reserves and former Pantepec concessions are now held by Creole, which also holds 100 per cent interest in the TT wells and 50 per cent joint interest with Mene Grande in the TH, TY, TR and TRN wells.

The discovery well, as well as most wells in the Temblador field, is on the northern upthrown side of a major regional fault, which was revealed by seismograph survey. The development of the field was guided mainly by reflection seismograph and subsurface geological work. Production is obtained from sands in the upper part of the Oficina formation.

OIL RESERVES

Producible reserves of Venezuela at the beginning of 1954 stood at 9,900 million barrels, according to Government figures—an increase of 446 million barrels over a year earlier. While the amount of oil added to reserves annually has more than replaced that produced in each of the past several years, the ratio of current reserves to output has been declining as a result of the heavy withdrawal rates of recent years. Expansion of the Venezuelan oil industry since the war period has indeed been enormous. Out of a total output since 1917 to 1952 of 6834 million barrels, 40 per cent, or 2805 million barrels, was accounted for in the 5-year period 1948-1952. In other words, the country produced in those 5 years as much oil as was won in the first 31 years of its oil history.

Annual output in the eariler period averaged 14.6 million barrels; in the post-war period it climbed to 561 million barrels, or 320 per cent higher. Following these greatly augmented withdrawals the ratio of reserve to production declined from 17.1 in 1949 to 14.3 in 1952.

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Venezuelan Oil Production and Reserves

Year	Additions to reserves	Annual production	Remaining reserves at year-end	Ratio of reserves to production
1948	839,160	490,770	7,656,390	15.6
1949	1,074,150	483,210	8,247,330	17.1
1950	1,034,460	547,470	8,734,320	16.0
1951	934,290	623,070	9,045,540	14.5
1952	1,068,950	660,490	9,454,000	14.3
1953	—	—	9,900,000	—

DRILLING PROGRESS

During the 6-year period ending 1953 the Venezuelan oil industry enjoyed an overall success of around 85 per cent in well completions. It drilled 5745 wells, of which 4873 were producers. The best year was 1952, when 88.8 per cent of wells drilled turned out to be producers and the leanest was 1950 with 79.2 per cent. On the average, 95 out of every 100 field wells, 80 out of 100 stepouts and 34 out of every 100 wildcats were completed successfully during the 1948-53 period.

One significant factor in the high proportion of successful completions is that in Venezuela the concessions of individual companies cover large blocks of acreage, and most fields are operated by single companies, or as units by several of them. Offset problems arise now and again, but competition is not keen by U.S. standards. The result is that each operator develops at more or less his own pace the acreage over which he has rights. Wildcats are drilled only after heavy expenditures of time and capital on prospecting and even development locations are thoroughly studied beforehand.

In development drilling successful completions ranged from 90.5 per cent in 1948 to 96.6 per cent in both 1951 and 1952. Semi-exploratory wells were somewhat less successful. Success with new field and new pool wildcats was marked, especially in the last two years when 40 to 42 per cent of all wildcat wells were brought in as producers. Analysis of the relative proportions of the three types of wells displays a trend away from development drilling and toward increased percentages of stepout and wildcat completions. Field wells accounted for nearly 75 per cent of all 1948 completions, but only a little more than half in 1953. Wildcats were only 6 per cent of the total completions in 1948, but 14 per cent in 1953. Stepout drilling had risen by 10 per cent over the last six years:

NATURAL GAS RESERVES

Venezuelan gas reserves showed a substantial rise in 1953 after 6 years of mainly deficits. They were estimated 18.2 billion cubic feet at the beginning of 1954, the highest figure since 1948 when the total was 22 billion cubic feet. Of the gas produced in 1953, 23.4 per cent was utilized (17 per cent in 1952) and the rest flared. It is certain that gas waste will be reduced in the coming years. The latest projected move in this direction is a State-sponsored petrochemical plant to be located in eastern Venezuela to produce agricultural fertilizer.

Only about 35 million cubic feet per day of gas is used in Venezuela as industrial or domestic fuel, apart from that utilized by the oil companies themselves. The greatest amount of gas consumption is by reinjection or pressure maintenance plants, of which 17 were in operation or under construction. Among the latter is Creole's installation in Lake Maracaibo which will return 137 million cubic feet per day to the Eocene B-6-X reservoir and of the LL-370 area of the Bolivar Coastal Fields. This will be nearly four times as big as the largest plant presently operating in the country and the largest such operation in the world. Close on 300 million bbl of otherwise unrecoverable oil have thus been added to the country's ultimate reserves.

New plant and important extensions added in 1953 included (1) for reinjection to the L-4 sand of Chimire field, 35 million cubic feet a day planned by Mene Grande Oil Company for itself, Creole and Socony Vacuum Oil Commany Inc; (2) extension of Phillips Petroleum Company's installation at San Roque field to raise capacity to 25 million cubic feet per day reinjected to the Colorado A and C sands; and (3) Mene Grande's plant in Nipa field, returning 5½ million cubic feet per day to the Gand L-2-M sands.

A water-injection plant was commissioned by Shell in 1953 to flood a portion of the Cabimas field with 6000 bbl a day water. Creole commenced similar experiments at Jusepin. The initial phase of an operation whereby 12 million cubic feet per day will be returned to the subsurface in Mapiri field was launched by Mene Grande last December (1953). This company is also planning similar installations in Boca, Dacion, La Vieja, El Toco, and Santa Rosa fields.

A byproduct of the erection of pressure-maintenance plants in the last decade has been the recovery in stabilization plants of natural gasoline from gas. This may be exported further refined, or injected into the crude to raise its gravity.

In mid-1954 there were 11 stabilization plants in operation, ranging in capacity from Creole's small installation at Cumarebo processing approximately 5 million cubic feet and extracting 110 barrels of natural gasoline a day to Mene Grande's West Guara unit handling 50 million cubic feet and recovering 1400 bbl of gasoline per day. The average recovery factor for all these units was about 1.5 gal per MCF. Additions to plant in 1953 raised this factor from 1.298 gal per MCF at the beginning of the year to 1.560 in December. Natural gasoline recovered by stabilization rose during 1953 from 266,000 bbl in January to 326,600 in December, and total for the year was 145 million gal.

Liquefied pertoleum gas (LPG) is pumped through submarine discharge lines as part of the scheme to improve fuel supply to Caracas. Propane is shipped in bulk by tanker from the Shell Cardon refinery to a 980 bbl capacity storage installation about 10 miles from the capital. Here the cargo is discharged through a 4-in. submarine line some 440 yd long. Water is pumped through a second pipeline into the cargo tanks of the tanker and so pushes the liquid propane through the discharge line to the storage tanks on shore. An automatic water separator prevents the discharge water from passing through to storage tanks. The liquid gas is thence pumped through to the storage tanks. The liquid gas is later pumped through a 10½-mile products line to a storage installation at Caracas which has a total capacity of 1960 bbl and where facilities are available for bottling the propane in cylinders.

(Look for Part 2 soon.)

	Total completions			Development wells			Wildcats			Drilled stepouts		
Year	Total	Producers	% Success	Drilled	Producers	% Success	Drilled	Producers	% Success	Drilled	Producers	% Success
1948	887	752	84.8	650	588	90.5	55	14	25.5	182	150	82.4
1949	682	548	80.4	426	386	90.6	71	19	26.8	185	143	77.3
1950	677	536	79.2	442	404	91.4	60	14	23.3	175	118	67.4
1951	1208	1054	87.3	826	798	96.6	112	34	30.4	270	222	82.2
1952	1340	1190	88.8	928	898	96.6	117	47	40.2	295	245	83.1
1953	951	793	83.4	516	492	95.3	134	56	41.8	301	245	81.4
Average	958	812	84.8	631	594	94.7	92	31	33.5	235	187	79.8

Exploration, Drilling, Producing

Wilcox Trend Conference

Eighth Oil Recovery Conference of the Texas Petroleum Research Committee, studying the Wilcox Trend, will convene April 4 and 5. Problems will be discussed in varied fields, ranging from geology to control of oil-gas ratio, gas-marketing problems, use of satellite absorbers, drilling problems and completion procedures. Meeting will be on the campus of Texas A and M College at College Station.

★ ★ ★

Historic Lease Abandoned

In memoriam: One of the greatest leases in the history of petroleum has been declared abandoned by Union of California. The discovery well, Lake View, No. 1, near Maricopa, California, blew in on March 15, 1910, spouting 125,000 bbl in its first day. The well produced nearly 9,000,000 bbl in first 18 months, averaging more than 50,000 bbl daily, from the 2200 ft Maricopa sand. The influx of oil from the well drove crude prices in the area to 30 cents per bbl.

★ ★ ★

AAPG Officers Named

G. M. Knebel, Jersey Standard, will become thirty-ninth president of the American Association of Petroleum Geologists at the close of the organization's annual meeting in New York City March 31. Serving with Knebel as vice president will be H. D. Thomas, Wyoming Geological Survey. W. A. Waldschmidt, consulting geologist, will serve as secretary-treasurer, and W. C. Krumbein, professor of geology at Northwestern University, will edit the AAPG Bulletin. Retiring president is Edward A. Koester, consulting geologist.

★ ★ ★

Penn Grade Crude Pushed

In the wake of Penn Grade crude price increase by 12 to 15 cents per barrel has come plans for an extensive national advertising campaign. Foreign sale of Pennsylvania oil products is strong, particularly in Europe. Research now being carried on, in line with present demand for lower viscosity oils, is seeking to convert heavy Penn cylinder stocks into neutral oils, without producing low-value by-products, by a process of molecular resizing.

Appalachians Surveyed

For the first time in the Appalachian area, seismographic recordings are being used by Ohio Fuel Gas Company. At present still in a testing stage, the method, which utilizes new and more sensitive equipment, is expected to be of value in mapping underground formations both for exploration and possibe storage.

★ ★ ★

More Deep Drilling

Trend toward increased deep drilling is continuing, based on inquiries directed to Thomas P. Pike Drilling Company, Los Angeles, California. The company now has 14 rigs at work in West Coast fields.

★ ★ ★

Oklahoma City Waterflood

Water flood project and unitization proceedings are under way in the South Wilcox unit of Oklahoma City, Oklahoma. Cities Service, Sinclair, Continental and Phillips hold the 2150 acres involved in the down-structure type flood, expected to yield an additional 10,000,000 bbl of oil from 69 producing wells. Actual work awaits state approval and ratification of 3700 royalty owners.

★ ★ ★

Oil Field Studies

Splendid work by the Rocky Mountain Association of Geologists in the preparation of their book, *Oil and Gas Fields of Colorado,* should lead other regional associations to similar undertakings. Handsomely bound and well presented, the book contains an introductory resume by A. E. Brainerd and F. M. Van Tuyl, reviewing the complete oil and gas production and exploratory development since oil was first discovered in Colorado in 1862. Geologic history of the state is written by F. A. Thurman and thorough individual field studies are included.

Issued since the Colorado book is an interesting study presented by the Second National Bank of Houston. It is entitled: "Production History of the Principal Oil Producing Formations in Arkansas, Louisiana, Mississippi, New Mexico and Texas." This booklet came from information secured by the AIME and the Texas Railroad Commission.

API Groups in Session

American Petroleum Institute's division of production from two areas will go into spring meetings this month. Southwestern district will be in session in New Orleans March 9-11. The Mid-Continent district, meeting in Amarillo, Texas, March 23-25, will hear addresses by Rex Baker, vice president of Humble Oil and Refining Company; J. Ed Warren, National City Bank of New York vice president and one of President Eisenhower's advisors on fuels, and Ernest O. Thompson, chairman of the Texas Railroad Commission.

★ ★ ★

Lease Play in Oregon

Oregon has over 1,000,000 acres under lease for oil and gas exploration —most of this leasing done since last July. Look for extensive drilling activity in this state soon, Oregon state department of geology and mineral industries suggests.

★ ★ ★

Australian Exploration

In the Northwest Basin of Western Australia, the West Australian Petroleum Pty., Ltd., has abandoned its Rough Range No. 6 at 3664 ft, but is planning a series of structure holes to approximately the same depth. Odor and sand fluorescence in the No. 6 well, and oil show in the No. 1 at around 3600 ft, have been sufficient to justify further exploration in the area.

★ ★ ★

Nortex Buys Holdings

A $1,000,000 deal has been closed giving to Nortex Oil and Gas Corporation, Dallas, Texas, 26 producing wells and some 1600 leasehold acres in Montague County, Texas. Production, previously owned by George S. Engle, yielded more than 20,000 bbl monthly.

★ ★ ★

California Men Organize

Long Beach Petroleum Club has been been organized for the oil men of Southern California. Facilities are being provided for a total membership of 350, and construction has begun on a new structure containing 6000 sq ft of floor space.

BAKER *Tools for Today's Operations*

BAKER OIL TOOLS INC. — BAKER — SERVING THE WORLD

Here are a few of the most outstanding Baker Oil Tools for 1954. Complete details, illustrations and specifications are in your new 1954 Composite Catalog, starting on Page 435, where many other important Baker Products will be found.

▶ No other product has proved so successful for so many applications as the BAKER RETAINER PRODUCTION PACKER, which can be set on tubing, drill pipe, or on a wire line. Look on Page 496 of the 1954 Composite Catalog to learn how it is used for single-zone or dual-zone production; as a squeeze tool for acidizing or cementing; as a tubing anchor and as a bridge plug.

▶ For placing cement slurry, plastic, acid or other fluids, the BAKER RETRIEVABLE CEMENTER provides a safe, positive "Hold-Down Type" Packer which operates mechanically rather than by fluid pressure. Look on Page 495 of the 1954 Composite Catalog.

▶ BAKER CASING BRIDGE PLUGS can be set on tubing, drill pipe, or on a wire line to provide either a permanent or a temporary bridge plug which prevents either upward or downward movement of fluid or gas. Many other advantages are described starting on Page 474 of the 1954 Composite Catalog.

▶ No other product can equal the efficiency of the BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE for safely floating-in and landing casing strings of any length. Removes bridges, washes the formation, and imparts a "whirling" action to the slurry. See Page 438 of the 1954 Composite Catalog.

▶ With BAKER DIFFERENTIAL FILL-UP SHOES (or Collars) the casing is filled automatically as it is being run, to within 90% of the fluid level of the annulus. Eliminates the dangerous "Ram Effect" which may break down a potential lost-circulation zone. Permits the introduction of the action of a back-pressure valve at the discretion of the operator, for floating (if desired) and for cementing. Ask any Baker office for brochure containing complete details.

▶ BAKER FLEXIFLOW FILL-UP SHOES (or Collars) permit filling the casing automatically as it is being run, while maintaining a relatively constant level of dry (unfilled) casing until the casing has been landed. It is then possible to bring the Bakelite Ball Valve into play as a back-pressure valve for floating and/or cementing when desired. This latest Baker development is illustrated and described in a folder available upon request from any Baker office.

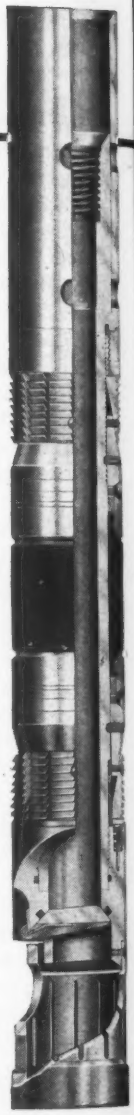
▶ For successfully placing cement or fluid at the place where it will be most effective, the BAKER CEMENT RETAINER has been "standard equipment" in International oil fields for many years. Read of its many uses starting on Page 474 of the 1954 Composite Catalog.

▶ The importance of having the I.D. of casing free from gun-shot burrs, hardened rotary mud and mill scale is evident from the rapidly increasing use of BAKER ROTO-VERT CASING SCRAPERS. Can be run easily and safely on drill pipe, tubing or a wire line, and leaves the "working surface" of casing clean and smooth for all future operations. Look on Page 517 of the 1954 Composite Catalog for details.

▶ When the time comes to center casing *positively*, and provide a uniform annular space for successful cementing, you need BAKER HINGE-LOK CASING CENTRALIZERS. Made in four ranges to exactly meet your casing programs, with many features not found in other centralizers. Interesting facts and illustrations start on Page 462 of the 1954 Composite (or Baker) Catalog.

▶ Controlled removal of the mud cake throughout the intervals to be cemented is positive and safe when BAKER WALL SCRATCHERS are used. The "scratching" action is minimized while running-in, but the spring-loaded wires with maximum reach dig in for best results on the upstroke. See Page 472 of the 1954 Composite Catalog.

▶ Any drilling man will tell you how the BAKER DRILL PIPE FLOAT VALVE lengthens the life of wire lines and brake bands by relieving weight; how it prevents pulling "wet" strings; how it prevents or minimizes accidents in case the drilling string should part. See for yourself on Page 534 of the 1954 Composite Catalog.



Baker Retainer Production Packer
Product No. 415-0

Review of

Sub-Devonian Exploration

in the Northern Appalachian Basin

Douglas Rogers, Jr.

IN May, 1947, the Pittsburgh Geological Society held an Ordovician symposium in Pittsburgh, Pennsylvania, which presented several interesting geological papers[1] dealing with the possibilities of oil and gas in rocks of Ordovician age, or older, underlying the Appalachian Basin. This was the first organized effort to review and correlate all available information on the sub-Trenton in this region. Valuable data such as regional isopach and lithofacies maps of the various important Ordovician and Cambrian units were presented.

Over the past 80 years most of the Appalachian oil and gas production east of the Ohio and western New York lower Silurian fields has been found in Pennsylvanian, Mississippian, and Devonian sediments. The Silurian has persistently failed to pay off in the deeper part of the Basin, and the only Ordovician production of any importance has been the discovery at Rose Hill in the southwest corner of Virginia where Pennsylvania Grade crude oil is produced from middle Ordovician limestones. Small Trenton lime gas discoveries were made in the central New York area many years ago, apparently emanating from fractures or small reefs, but the production was of only local importance. In the early 1940's such companies as Sinclair, Magnolia, and The Texas Company drilled a number of deep tests in southeastern Ohio and in West Virginia seeking Silurian or Ordovician oil and gas. This drilling was preceded by intensive lease plays and considerable seismograph and geological study but was unsuccessful in developing deep production. In the middle 1940's The California Company entered the Basin, first in eastern Kentucky, then into the western part of Virginia, and finally into north-central Pennsylvania and south-central New York. Their exploratory efforts were the most intensive of any one company to date with large acreage spreads being acquired and an extensive amount of seismograph work being done. They drilled unsuccessful deep rotary tests in western Virginia and north-central Pennsylvania.

In 1947 a group headed by South Penn Oil Company and Tide Water Associated Oil Company began acquiring leases on a number of structures in West Virginia, Pennsylvania, and New York for the purpose of exploring sub-Devonian rocks. Since that time they have drilled three dry holes; two to the lower Silurian and one to the lower Ordovician, without commercial success, although their Schellsburg test in Bedford County, Pennsylvania, found a non-commercial gas pay in the Ordovician. Among other well known operators who have contributed to the general knowledge of these older rocks during recent years have been Benedum-Trees, Snee & Eberly, Bradley Producing Company, Quaker State, New York Natural Gas Corporation, Hope Natural Gas Company, United Fuel Gas Company, and United Carbon Company.

The widespread interest which became aroused in Silurian and Ordovician possibilities following the Rose Hill, Virginia, discovery, has no doubt been somewhat tempered by a series of wildcat failures, but an even greater deterrent has been the discovery and development of the much publicized Leidy and Benezette Oriskany gas pools. Furthermore, an imposing succession of strikes in West Texas, the Williston Basin, and in Western Canada, has had the effect of drawing the interest of many operators away from the eastern areas. The above factors have no doubt been at least partly responsible for the decrease in sub-Devonian exploration in the Appalachians in recent years.

The purpose of this article is to summarize and review some of the more

EXCLUSIVE *Sub-Devonian exploration in the northern part of the Appalachian Basin has thrown considerable light on the characteristics and potentialities of Silurian, Ordovician, and Cambrian formations. It is believed that as a widespread objective the lower Ordovician and upper Cambrian hold the most promise, but middle and upper units of the Ordovician may prove productive in certain areas. Medina and Williamsport sands of the Silurian have secondary ratings but may yield commercial quantities of gas in places.*

important sub-Devonian tests drilled in the northern part of the Appalachian Basin during the past seven years. It will also attempt to comment on the results of this exploration and perhaps to indicate trends of geologic thinking and the future possibilities.

Drilling in the Clinton sand fields of Ohio will not be covered since that production lies on the western rim of the Basin and is long-established even though much successful extension work has been accomplished in the past two years, largely as a result of the hydrafrac completion process.

For convenience the Basin will be divided into three major geological provinces which are shown on the map, Fig. 1, together with the location of the important deep tests described in this review. A brief description of the areas follows:

Folded Valley and Ridge Province

The folded mountain area, often referred to as the Valley and Ridge Province, lies east of the Appalachian structural front. The region is complicated by intense folds and thrust faulting, with rocks of Pennsylvanian to Cambrian age exposed, and large structural features numerous. Wildcatters are able to explore virtually any part of the geologic section due to the extensive breaching of the anticlines. It was only logical that because of the magnitude of the structural closures and the variety of drilling depths available, this should be one of the preferred areas for sub-Devonian exploration. However, this region has a number of disadvantages in that the rocks tend to be more indurated, the steep dips prove troublesome to both cable tool and rotary operations, and the geological complications frequently lead the operator into serious difficulties with the ultimate depths of many of the wells being considerably in excess of that originally anticipated as a result of thickening induced by thrust faulting or intense folding.

Eastern Allegheny Plateau

West of the Valley and Ridge Province lies the Allegheny Plateau, the eastern portion of which is characterized by moderately strong folds, some exhibiting an exceedingly complex attitude at the Oriskany level. There is a sharp line of demarcation between the more gently folded plateau area and the strongly folded Valley and Ridge Province. This line of demarcation, referred to generally as the Appalachian structural front, can be followed throughout the length of the Basin and no doubt has some deep-seated structural significance. Wells on the plateau must start in rocks of Pennsylvanian and upper Devonian age and have to penetrate some 6000-8000 ft of Devonian sediments before reaching Silurian beds. Therefore, even though there are many structures which exhibit attractive closures, the sub-Devonian exploration in this province has been confined to those places where the deeper rocks can be reached at economically feasible depths. In addition to the depth problem the complexity of the fault patterns exhibited by some of the domes on which Oriskany gas is produced in eastern West Virginia and

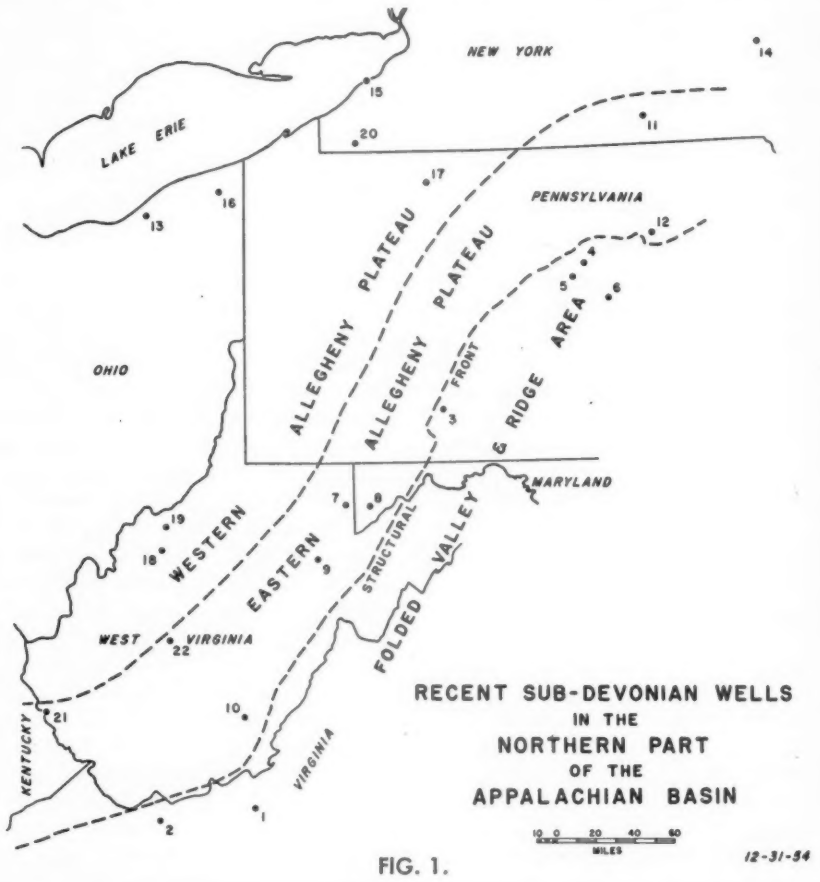


FIG. 1.

TABLE 1. List of recent significant wells testing Sub-Devonian rocks in northern part of Appalachian basin.

Map No.	Well name	Well No.	Operator	County	State	Year comp.	Drilling equipment	Total depth	Deepest formation tested
1	Kippe Anthracite Coal Co.	1	The California Co.	Montgomery	Va.	1949	Rotary	9,340	Moccasin Limestone—Middle Ordovician
2	J. M. Hogue	1	United Carbon Co.	Tazewell	Va.	1950	Cable Tools	5,632	Shady Dolomite—Lower Cambrian
3	Jesse B. Miller	1	South Penn—Tide Water	Bedford	Pa.	1952	Cable Tools	8,980	Beekmantown Dolomite—Lower Ordovician
4	W. E. Snyder	1	Snee & Eberly	Lycoming	Pa.	1951	Cable Tools	5,808	Warrior Dolomite (?)—Middle Cambrian
5	Clifford Walizer	1	Deep Rock Oil Corp.	Clinton	Pa.	1953	Rotary	4,532	Gatesburg Dolomite—Upper Cambrian
6	Reno Solomon	1	Godfrey L. Cabot, Inc.	Union	Pa.	Drlg.	Cable Tools	4,302	(Drilling in Reedsville Shale)—Objective: Lower Ordovician
7	Virginia Cuppett	1	Snee & Eberly	Preston	W. Va.	1948	Cable Tools	8,942	Medina Sand—Lower Silurian
8	John K. Shaw	2	New York State Natural	Garrett	Md.	1952	Cable Tools	7,162	Medina Sand—Lower Silurian
9	J. W. Isner	1	South Penn—Tide Water	Randolph	W. Va.	1950	Cable Tools	6,095	Rose Hill Formation—Middle Silurian
10	Bertha Thornbury	1	Deep Rock Oil Corp.	Greenbrier	W. Va.	1953	Cable Tools	7,490	Williamsport Sand—Middle Silurian
11	E. C. Kesselring*	1	New York State Natural	Chemung	N. Y.	1953	Cable Tools	11,145	Gatesburg Dolomite—Upper Cambrian
12	A. W. Bennett***	1	The California Co.	Sullivan	Pa.	1951	Rotary	12,343	Medina Sand—Lower Silurian
13	M. Eichenberg	1	Benedum-Trees	Cuyahoga	Ohio	1949	Cable Tools	5,740	Gatesburg Dolomite (?)—Upper Cambrian
14	Clarence Lobdell	1	Bradley Producing, et al	Chenango	N. Y.	1949	Cable Tools	5,701	Granite (or Granite Wash)—Pre-Cambrian
15	Neihaus	3	Heintzelman, et al.	Chautauqua	N. Y.	1949	Cable Tools	4,511	Gatesburg Dolomite (?)—Upper Cambrian
16	George Corlett	1	Benedum-Trees	Ashtabula	Ohio	1951	Cable Tools	6,186	Gatesburg Dolomite—Upper Cambrian
17	L. D. Wilson	18	South Penn Oil Co.	McKean	Pa.	1948	Cable Tools	8,002	Oswego Sand—Upper Ordovician
18	Cora Brown**	1	United Fuel Gas Co.	Wirt	W. Va.	1954	Rotary	8,206	Medina Sand—Lower Silurian
19	Power Oil Co.**	9634	Hope Natural Gas Co.	Wood	W. Va.	Drlg.	Rotary	13,000*†	Drilling in Cambrian—Objective: Basement
20	Kyle Morse	1	Glaros & Katros	Chautauqua	N. Y.	1955	Cable Tools	7,100	Testing Cambrian and Medina gas shows—Gatesburg Dolomite (?)—Upper Cambrian
21	F. D. Caldwell	6181	United Fuel Gas Co.	Wayne	W. Va.	1949	Cable Tools	7,900	Gatesburg Dolomite—Upper Cambrian
22	United Fuel Gas Co. Fee**	8000-T	United Fuel Gas Co.	Clay	W. Va.	1953	Rotary	8,144	Medina Sand—Lower Silurian

* Deepest cable tool hole in the world.
** Cable tool hole through Oriskany (Lower Devonian). Drilled deeper with rotary tools.
*** Deepest well in the Appalachian Basin.

north-central Pennsylvania gives reason for caution in projecting wells to deeper horizons.

Western Allegheny Plateau

This area, for the most part, lies west of the Warfield-Chestnut Ridge-Wellsboro anticlinal trend which can be traced throughout West Virginia, Pennsylvania, and into New York State. This line of folding in most areas marks the approximate western limit of the moderately intense folds that characterize the eastern part of the plateau. West of this line the folds tend to lose their character and become irregular flexures, noses, and low-lying domes, on the southeasterly regional dip.

Most of the shallow upper Devonian oil and gas sands occur in this area, but these produce mainly from stratigraphic traps which appear to have little direct relationship to Appalachian folding. Were it not for the apparent lack of well-defined, prominent structures, this province would appear to be the most favorable exploratory area for sub-Devonian oil and gas. Regional migration of Ordovician and Cambrian hydrocarbons could be expected to occur up-dip into this flank of the Basin, and the possibility of large stratigraphic traps below regional unconformities is ever present. While the depths are not as prohibitive as in the easterly plateau province, they are nevertheless formidable, requiring the drilling of 10,000 to 15,000-ft wells. Through detailed geological studies and more precise geophysical methods there is a possibility of finding early folding in the Ordovician and Cambrian rocks which may have trapped oil and gas accumulations. Interestingly enough, a majority of the Ordovician or Cambrian tests on this western flank of the Basin have had significant shows of oil and gas in porous dolomites or sands of those ages. The difficulty seems to lie in localizing important structural or stratigraphic traps.

The remainder of this paper will be devoted to describing in some detail the important sub-Devonian tests which have been drilled in recent years in each of the above provinces. (Table 1)

Wells Drilled in the Folded Valley and Ridge Area

The California Company—No. 1 Kipps Anthracite Coal Company (Fig. 1, No. 1) In 1949 The California Company moved a large rotary rig into a location on Price Mountain in Montgomery County, Virginia, about 4 miles southwest of the town of Blacksburg. This well was drilled in the center of an oval-shaped fenster in which are exposed Mississippian sediments entirely surrounded by Cambrian limestones and dolomites of the Pulaski low angle thrust sheet. The Mississippian rocks, which are more resistant to erosion than the surrounding limestones and dolomites, form a prominent topographic feature known as Price Mountain. Outcrops of Mississippian within the erosional "window" of the overthrust sheet exhibit anticlinal closure and it is possible that the fault plane itself may have been warped by folding. Due to the thick section of Silurian quartzites drilling progress on this test was rather slow with an overall average of 34.5 ft per day.

The well apparently encountered another low angle thrust repeating a member of the Trenton limestone, and it was abandoned as dry at 9340 ft while still in the Moccasin limestone of middle Ordovician. A show of gas estimated at 50,000 cu ft was encountered in the Trenton. The well is only 10 miles northwest of pre-Cambrian outcrops.

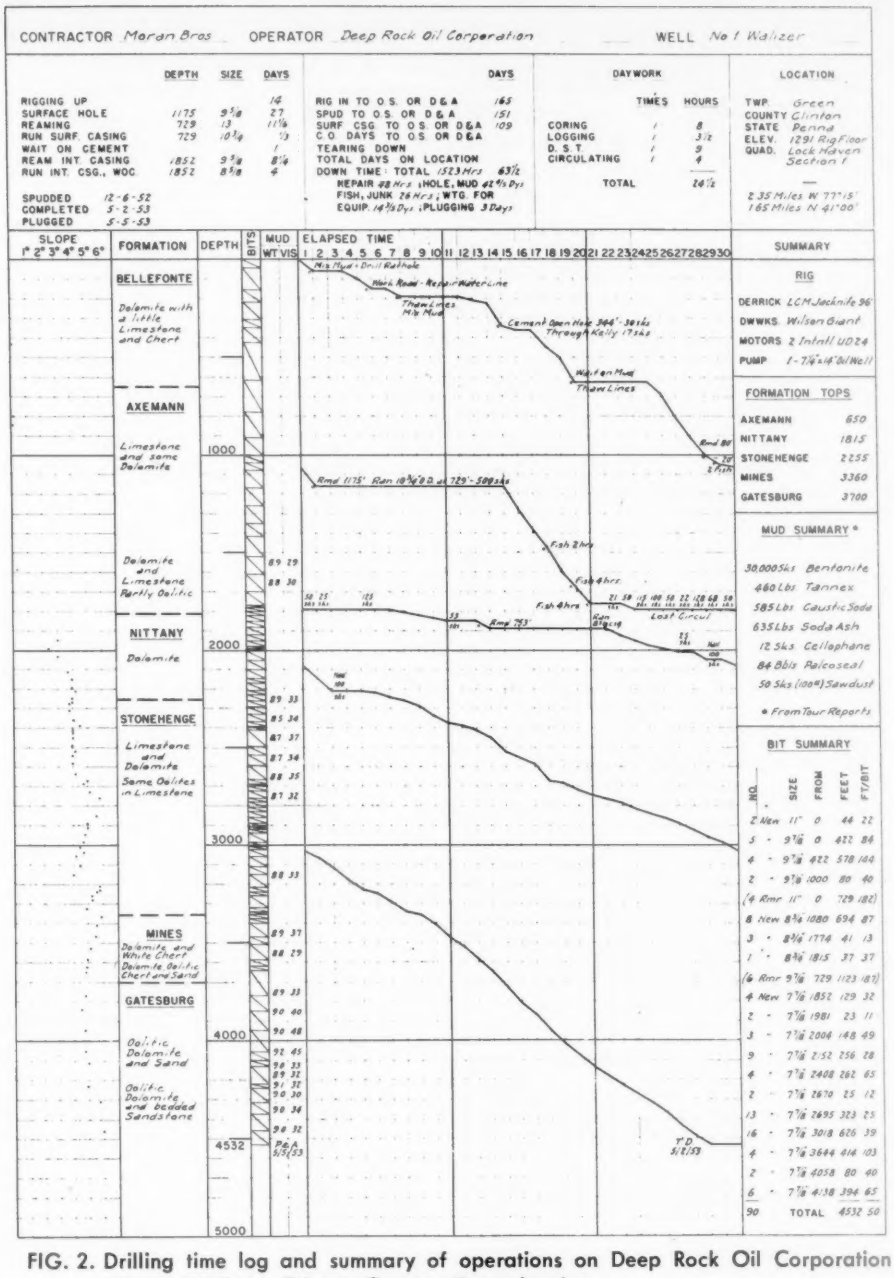


FIG. 2. Drilling time log and summary of operations on Deep Rock Oil Corporation No. 1 Walizer, Clinton County, Pennsylvania.

United Carbon Company—No. 1 J. M. Hogue (Fig. 1, No. 2) Also in 1949 the United Carbon Company started a deep cable tool test on the Burkes Garden Dome in Tazewell County, Virginia. This well spudded in middle Ordovician limestones and experienced a great deal of difficulty due to the cavernous nature of the surface rock, finally abandoning the first hole at a shallow depth and skidding the rig. This structure is a prominent one, appearing on the topographic sheets as a basin about 4 miles long and 2½ miles wide. The well encountered recurrent flows of fresh water from the lower Ordovician and upper Cambrian dolomites as deep as 3500 ft below the surface. As the well was being drilled with cable tools, it necessitated reaming the

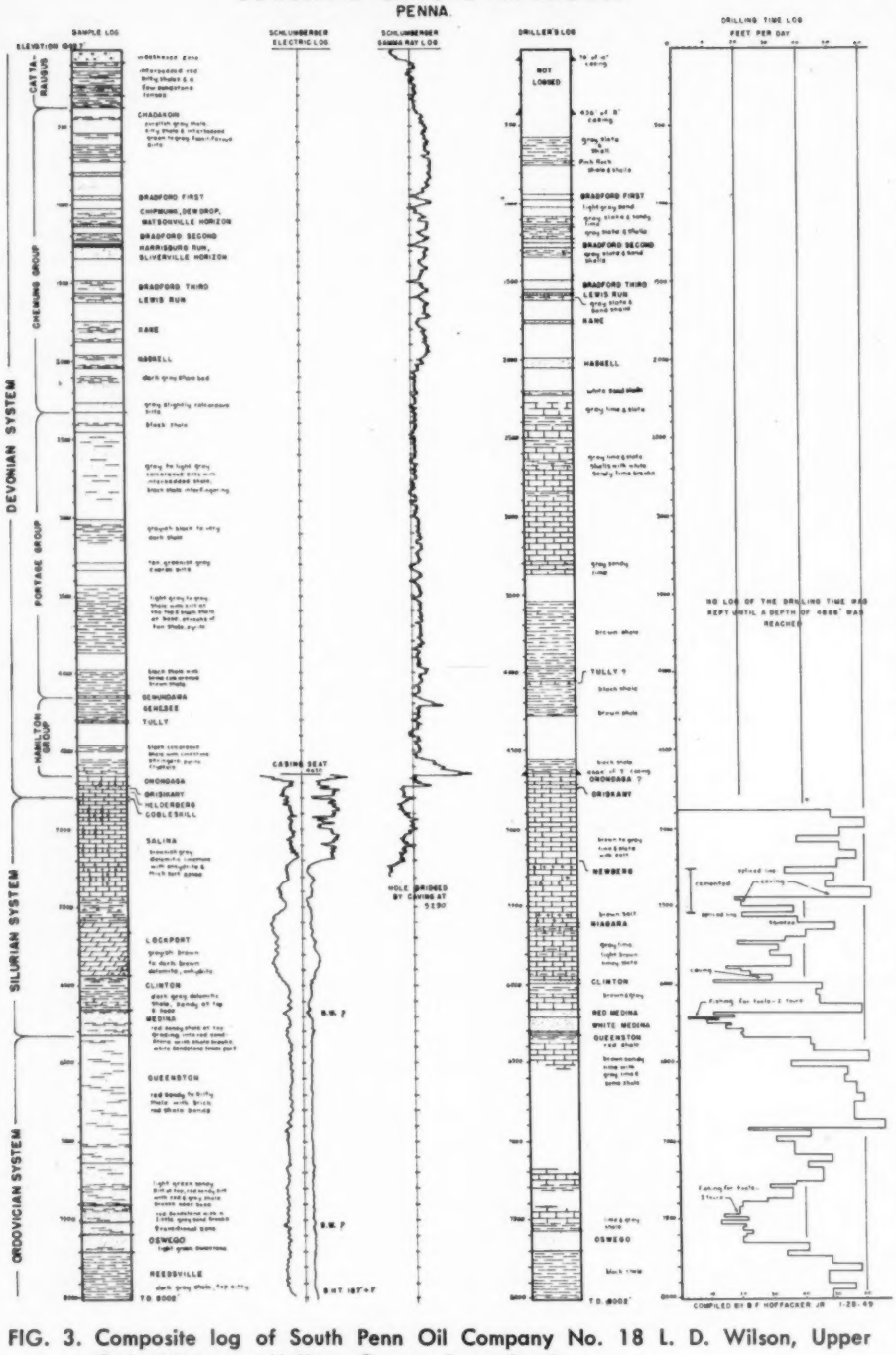


FIG. 3. Composite log of South Penn Oil Company No. 18 L. D. Wilson, Upper Ordovician test, McKean County, Pennsylvania.

hole and resetting of the water string on at least four occasions.

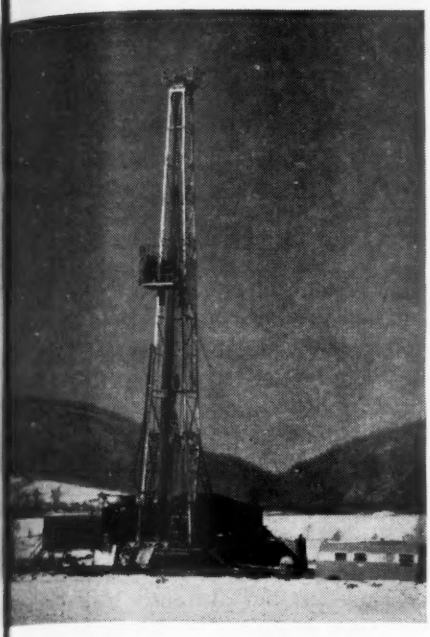
The objective of the well was the Copper Ridge (Gatesburg) dolomite of upper Cambrian age which, on the outcrop in nearby areas, contains traces of hydrocarbon residues. No shows, however, were noted in the Hogue well which was drilled on through into the Shady dolomite of lower Cambrian where it was finally abandoned at 5632 ft. Considerable crooked hole trouble was encountered in the bottom part of the hole with acid bottle tests indicating a maximum deviation of 14 deg from the vertical and repeated shooting of the hole did not seem to correct the situation. In crystalline portions of the Shady dolomite some oil staining, as well as waxy residue, was noted. Analyses indicated this material was derived from a paraffin base oil.

South Penn Oil Company—No. 1 Jesse B. Miller (Fig. 1, No. 3) In October, 1948, the South Penn-Tide Water group began a cable tool drilling operation on the Miller well which was located near the axis of the Schellsburg Dome in Bedford County, Pennsylvania. This is one of the most attractive surface structures in central Pennsylvania with closure of about 1200 ft. The structure is slightly asymmetrical to the northwest with a minor thrust fault on its northwest flank and Helderberg limestone of lower Devonian age exposed along its crest. The well had considerable difficulty getting through the cavernous limestones in the upper 200 ft of hole, but then made good progress through the upper and middle Silurian. At 3210 ft, after drilling the upper portion of the very hard Tuscarora (Medina) quartzite, the well penetrated a fault and repeated the entire thickness of the Tuscarora. A large volume of salt water encountered in the upper Tuscarora impeded drilling progress severely and a water string of 8-in. casing finally became necessary. Even after successfully drilling through the Tuscarora, progress was not very satisfactory since the Juniata and Oswego formations contained great thicknesses of hard, abrasive sandstones.

The Reedsville shale of upper Ordovician drilled fairly easily until extensive caving and gas pockets were encountered in its lower portion. A succession of fishing jobs ensued before the Trenton limestones were finally encountered at 7810 ft where 7-in. casing was set. The middle Ordovician limestones were drilled without difficulty and the Beekmantown dolomite was encountered at 8837 ft. Thirty-three feet below the top of this formation gas was struck, blowing the tools up the hole where they became jammed, requiring a long fishing job. The initial open flow of this Ordovician gas was approximately 600,000 cu ft, but within a few days this reduced to approximately 100,000 cu ft. The fishing job was long and difficult with the operations being hampered by the 4 per cent hydrogen sulfide content of the gas. After the tools were successfully recovered the well was shut in for 64 hours for a pressure test, whereupon the top joint of 7-in. casing suddenly shattered under a pressure of 1800 psi, probably as a result of hydrogen embrittlement. The casing was finally repaired and drilling proceeded carrying several thousand feet of water in the hole to lessen the corrosive effect of the sour gas on the cable tool drilling lines.

This procedure reduced line failures but also drastically cut down the penetration rate making further drilling impracticable. No additional pays were encountered although the volume of gas never decreased below 90,000 cu ft even though the well was open for more than a year before being abandoned. Unfortunately, due to the operational difficulties no samples of the pay zone were recovered, but it is believed to be a thin, porous dolomite section. An acidizing job failed to increase the flow of gas, and the well was abandoned in the spring of 1952.

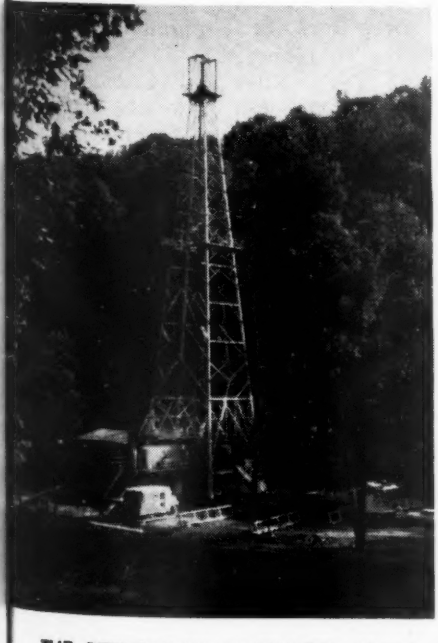
It is interesting to note that the total time between spudding and completion



Deep Rock Oil Corporation's No. 1 Walizer Cambrian test on Sugar Valley Anticline, Clinton County, Pennsylvania. Ridge seen in the background is capped by lower Silurian sandstone.

View of New York State Natural's No. 1 E. C. Kesselring Cambrian test on Van Etten Anticline, Chemung County, New York. Deepest cable tool well in the world. TD, 11,145 ft.

Hope Natural Gas Company's No. 9634 Power Oil Company Cambrian test in Wood County, West Virginia. Drilling below 13,000 ft.

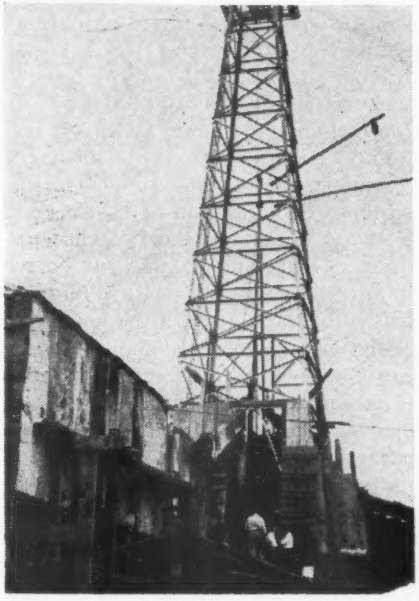


was 1247 days. A breakdown of this overall time is shown in Table 2.

An analysis of the penetration rates based on actual drilling time is listed in Table 3.

Analyses of the gas showed a 38 per cent nitrogen content, the rest being mostly methane with a trace of heavier hydrocarbons.

Snee & Eberly—No. 1 W. E. Snyder (Fig. 1, No. 4) This well was a farm-out by The California Company with bottom hole contributions by the South Penn-Tide Water group. It was drilled in 1950-1951 and was located on the Nippenose Dome in Lycoming County, Pennsylvania. A well-defined symmetrical closure 12 miles east of Lock Haven, Pennsylvania, the structure is capped by Beekmantown dolomite of lower Ordovician age. The Snyder No. 1 was drilled to a total depth of 5808 ft and reached the middle Cambrian. The well took about one year to



drill to this depth and encountered severe crooked hole difficulties in the lower 300 ft. In this lower section there were indications that the well was approaching a major fault zone as samples contained severely brecciated dolomite. The average inclination of the hole was 23 deg in the bottom 1500 ft. This well encountered recurrent zones of water in the upper part of the hole, necessitating pulling and rerunning the water strings on several occasions. Minor shows of gas were encountered in the sandstones and dolomites of the Gatesburg formation of upper Cambrian age with the highest test being 23,000 cu ft. As in the Miller well, this gas contained a high nitrogen content, in this case 26 per cent, with the remainder consisting of methane, and only a small amount of the heavier hydrocarbons. Before abandonment the Snyder well was acidized without success.

Deep Rock Oil Corporation—No. 1 Clifford Walizer (Fig. 1, No. 5) In the latter part of 1952 Deep Rock Oil Corporation began drilling a rotary test on a farm-out from the South Penn-Tide Water group on the Sugar Valley structure in Clinton County, Pennsylvania. This well is about 10 miles southeast of Lock Haven on a fold which is essentially *en echelon* with the Nippenose Dome. A drilling time summary of this well is shown in Fig. 2. Numerous lost circulation difficulties were encountered in the upper 2000 ft of hole. A mud logging unit employed on this location recorded one show of gas which, upon drillstem test, turned out to be only a pocket. The well bottomed in the Gatesburg at 4532 ft. Ninety rock bits were used with average per bit of 50 ft.

Godfrey L. Cabot, Inc.—No. 1 Reno Solomon (Fig. 1, No. 6) This well was spudded with cable tools in October, 1953, as a farm-out from The California Company on the Shamokin anticline northwest of Sunbury, in Union County, Pennsylvania. It is located on the axis of this prominent structure which is capped with Tuscarora (Medina) sandstone of lower Silurian age.

The well to date has drilled 492 ft of Tuscarora, 1796 ft of Juniata (Queenston), and 952 ft of Oswego sandstone. It was last reported at a depth of 4302 ft, 1062 ft in Reedsville shales of upper Ordovician age, and its objective is the Beekmantown dolomite of lower Ordovician. Progress has been slow due to the hard, thick sandstones of the lower Silurian and upper Ordovician, most of which were drilled with a hole full of fresh water. These water pays were encountered periodically down to a depth of 2450 ft, and apparently emanate from fracture systems which permeate the above-mentioned sandstone units. An 8-in. water string was run at 2444 ft in the hard Oswego in order to speed up the drilling rate but unfortunately fresh water was again found below that depth so the Reedsville shales are being drilled with a water-filled hole. Fortunately shales have shown no tendencies to cave and it

TABLE 2. Summary of Total Elapsed Time—Jesse B. Miller No. 1.

	Days	Per cent of total
Drilling	699	56.0
Repairs and installations	52	4.2
Vacations and holidays	68	5.4
Fishing jobs	320	25.7
Shut downs	108	8.7
Total	1247	100.0

TABLE 3.

Depths	Section drilled	Ft/day	No. days
0-270	Cavernous Limestone	6	42
270-2850	Cavernous Limestone to Tuscarora	48	54
2850-5600	Tuscarora to Reedsville	11	251
5600-7800	Reedsville to Trenton	15	147
7800-8870	Trenton to gas zone	18	58
8870-8980	Gas zone to total depth	.7*	147
	Total	12.8	699

* This interval was drilled under a hole full of water.

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is hoped that the well can be carried on to the Ordovician dolomites.

Of particular interest is the fact that several shows of oil were encountered in the lower part of the Juniata red beds, apparently emanating from the fracture system with large volumes of water. Because it is well situated stucturally, this test is of considerable interest to the industry.

Wells Drilled in the Eastern Allegheny Plateau Area

United Fuel Gas Company—No. 6181 F. D. Caldwell (Fig. 1, No. 21) This cable tool sub-Trenton test was located on the Warfield anticline in Wayne County, southwestern West Virginia, and took more than two years to complete, being finally abandoned in September, 1949. The well reached a total depth of 7900 ft and penetrated 769 ft into the Cambrian. A number of shows of oil, gas, and salt water was encountered in these dolomites and sandstones and drilling was finally stopped when a large volume of salt water was encountered at 7887 to 7900 ft. Repeated wire line failures, probably caused by sour gas, made the lower section extremely expensive.

Snee & Eberly—No. 1 Virginia Cuppett (Fig. 1, No. 7) In Preston County, West Virginia, the Terra Alta structure, which produces gas from the Oriskany and Huntersville chert of the Devonian, received a Medina test in 1948, when Snee & Eberly deepened their No. 1 Virginia Cuppett, a small Oriskany gas producer. The well topped the Medina at 8803 and was halted at a total depth of 8942 ft after finding no porosity in the lower Silurian sand. It was plugged back to the Oriskany level and later acidized into a commercial Oriskany-Chert gas well.

New York State Natural Gas Corp.—No. 2 John K. Shaw (Fig. 1, No. 8) This well is located in the Mountain Lake Park pool near Oakland, in Garrett County, Maryland, a field which also produces gas from the Oriskany and Huntersville Chert. Shaw No. 2 was a low-volume edge well and New York State Natural deepened it to the lower Silurian in the latter part of 1952. There was some disagreement on the top of the Medina with the scout reports carrying the top at 6972 ft and the Maryland Geological Survey at 7120 ft. Gas was encountered at 7140 ft and tested 116,000 cu ft. The well was shot and its open flow increased to 225,000 cu ft, but this exhausted after three month's time, and the well was abandoned after it became obvious that deepening the well through the remainder of the Medina was not feasible due to poor condition of the hole. This is the easternmost well to record any natural gas in the lower Silurian which makes it of interest even though the volumes were not of commercial importance. The total depth of this hole was 7162 ft.

South Penn-Tide Water—No. 1 J. W. Isner (Fig. 1, No. 9) This cable tool test on the large, complex Elkins structure was located about eight miles north of Elkins in Randolph County, West Virginia, and spudded late in December of 1948 with lower Ordovician as its objective. The well passed through an overthrust fault at 3003 ft repeating approximately 1200 ft of section including the lower Devonian and the upper Silurian. Excessive thickness of middle Silurian units indicated the existence of minor faults or steep dip in that section and the hole became crooked and difficult to drill below 5000 ft. Surveys indicated a southwest drift throughout most of the hole.

The well was finally abandoned early in 1950 at 6095 ft after four months of unsuccessful fishing for a lost bailer. Operators had attempted to carry an extra large hole and were using 10-in. bits when drilling was halted, which may have established some sort of a record for the amount of that size hole drilled by cable tools. At the time of its abandonment, the well was in the lower part of the Rose Hill formation, probably just above the Medina sand.

The California Company—No. 1 A. W. Bennett (Fig. 1, No. 12) This well, until recently the deepest in the Appalachian Basin, was located on the Muncy Creek structure in Sullivan County, Pennsylvania, about 25 miles northeast of Williamsport. It was drilled by Noble Drilling Company, using a National rotary rig Type 100, and spudded in March of 1951. It was abandoned in the Juniata formation of upper Ordovician in December of the same year after reaching a total depth of 12,343 ft with no important shows in any horizon. The Medina was tight and quartzitic with some interbedded sandstone and shale. The well required 214 rock bits, 9 conventional core bits, 12 diamond core bits, and averaged 48.7 ft per day overall.

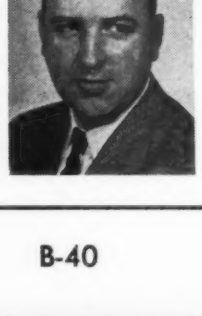
New York State Natural Gas Corp.—No. 1 E. C. Kesselring (Fig. 1 No. 11) This well, deepest ever drilled by cable tools and the fourth deepest hole in the Appalachian Basin, was located on the Van Etten structure in Chemung County, New York, about 15 miles northeast of Elmira.

It was primarily scheduled as an Oriskany test but operators had sub-Devonian horizons in mind in the event deepening became desirable. The venture spudded in June of 1948 and after finding only a small amount of gas in the Oriskany was taken down to the Medina and ultimately through the Oswego sand of upper Ordovician. Well was shut down in August, 1949, at a depth of 8371 ft. Drilling was resumed with extra heavy duty equipment in late November of 1951 and good progress was made through the upper Ordovician, slowing up somewhat below 9000 ft. Gas pockets were encountered in the Reedsville and Trenton sections but no further porosity was found until the well had passed the 11,000 ft mark and was drilling in Gatesburg dolomite of upper Cambrian. At 11,145 ft a large volume of salt water was encountered and the hole was abandoned at that depth in May, 1953. The operation set a new world record for cable tool depths and again demonstrated the existence of good porosity in upper Cambrian rocks.

Deep Rock Oil Corporation—No. 1 Bertha Thornbury (Fig. 1, No. 10) In 1952 Deep Rock Oil Corporation started a deep test cable tool on the Williamsburg structure in Greenbrier County, West Virginia, drilled by Columbia Carbon Company, acting as contractor. It encountered great difficulty in getting through the Devonian shales which proved to be severely fractured allowing surface water to penetrate to great depths.

After more than two years of drilling, the well was successfully completed with an open flow of 750,000 cu ft from the Oriskany and Williamsport sands. Following this discovery Columbian Carbon started two wells of its own on the structure, one of which has since been completed as a dry hole and the other well is still drilling with rotary tools.

The Author



Douglas Rogers, Jr., is chief engineer for the South Penn Oil Company of Bradford, Pennsylvania. He received his AB and MA degrees in geology from Cornell University and joined South Penn as a petroleum geologist with its West Virginia subsidiary, South Penn Natural Gas Company in 1941.

During the past eight years he has been closely connected with sub-Devonian exploration conducted by the South Penn-Tide Water Associated group in West Virginia, Pennsylvania and New York. He is a past president of the Appalachian Geological Society, member of the American Association of Petroleum Geologists, and at present is secretary of the API Eastern District Study Committee on Secondary Recovery.

Wells Drilled in the Western Allegheny Plateau Area

South Penn Oil Company—No. 18 L. D. Wilson (Fig. 1, No. 17) Near Tallyho, in McKean County, Pennsylvania, just south of the Bradford oil field, South Penn Oil Company completed an Oriskany dry hole in August of 1948 and then deepened the well to the Oswego sand of the upper Ordovician. Contractor had difficulty getting through Salina salt beds of upper Silurian because hole squeezed shut.

A summarized log of the well is shown in Fig. 3. An electric log was run below the 7-in. casing but contamination of the fresh logging water by the Silurian salt beds rendered the lower part of the log unsatisfactory. Moreover, filling the open hole with water caused it to bridge in the salt beds so that the gamma ray log and a seismic velocity survey could go no deeper than 5290 ft.

Bradley Producing Company—No. 1 Clarence Lobdell (Fig. 1, No. 4) Drilled jointly by Bradley, Quaker State, and New York State Natural Gas Corporation the Lobdell test was located in Chenango County, New York, about 30 miles south of Utica. No structural closures have been mapped in that area and although some magnetic anomalies were found to exist, the Lobdell No. 1 was for the most part a stratigraphic test. The well was drilled by cable tools in 1949 and was abandoned in granite wash at a depth of 5701 ft. Brackish water was encountered in several porous zones in the upper Cambrian dolomites.

Benedum-Trees—No. 1 M. Eichenberg (Fig. 1, No. 13) In 1949 Benedum-Trees drilled an interesting cable tool test in Cuyahoga County about ten miles east of Cleveland. This well was located on a known geologic structure which had been producing gas for many years from the middle Silurian Lockport dolomite ("Newburg"). It encountered oil pay in Cambrian dolomite between 5702-15 ft. The oil was a green-colored paraffin base type with a gravity of about 38 deg and rose 1100 ft in the hole causing considerable excitement. The pay was treated with acid but completion of the well was delayed by a fire which destroyed the rig. Initial potential was about 50 bbl per day, but production gradually dwindled to 5 bbl of fluid per day with a steadily increasing salt water cut and the well was finally abandoned.

Benedum-Trees—No. 1 George Corlett (Fig. No. 16) In 1951, in Ashtabula County, Ohio, 40 miles east of its Cuyahega County Eichenberg failure, Benedum-Trees drilled another sub-Trenton test. Like the Eichenberg, this well also penetrated sands and dolomites of Cambrian age below the middle Ordovician limestones but found only salt water.

Heintzelman etal.—No. 3 Neihaus (Fig. 1, No. 15) In 1949, near the shore of Lake Erie, three miles northeast of Dunkirk, Chautauqua County, New York, D. E. Heintzelman and Associates moved a cable tool rig into an abandoned Medina sand gas well for the purpose of cleaning it out and deepening it to the sub-Trenton. A number of small gas pays were encountered in sandy dolomite, probably of upper Cambrian age. This gas, which had an initial open flow of about 80,000 cu ft, was produced from porous zones between 4422 to 4487 ft. At last report salt water encroachment was impeding the flow of gas.

Hope Natural Gas Company—No. 9634 Power Oil Company (Fig. 1, No. 19) At Sand Hill on the eastern edge of Wood County, West Virginia, about 20 miles east of Parkersburg, the Hope Natural Gas Company is now drilling a rotary test which is being closely watched by the industry. This well is located on the well-known Burning Springs anticline which has a mapped closure of approximately 1000 ft and is one of the few strong surface features in the relatively undisturbed western part of the Allegheny Plateau.

This test was spudded in May of 1951 using cable tools and a large hole was carried to the Oriskany. Rotary operations were commenced in July of 1953 by Falcon-Seaboard, supported by dry hole contributions from Columbian Carbon Company, United Fuel Gas Company, Manufacturers Light & Heat Company, and South Penn Oil Co. Well is drilling below 13,000 ft.

Well has encountered a number of encouraging gas shows in the Ordovician-Cambrian section. Several drill-stem tests have been made of the porous zones, and the well cored continuously with diamond bits from 9790 to 11,684 ft.

The fact that this wildcat penetrates a completely unexplored geological section on a prominent structure in the petroliferous portion of the Appalachian region makes it undoubtedly one of the most important sub-Devonian wells ever drilled in the Basin. At its last reported depth of 13,000 ft on February 1, 1955, it was the deepest hole in the Appalachian Basin having surpassed the record set by California Company's No. 1 A. W. Bennett.

United Fuel Gas Company—No. 1 Cora Brown (Fig. 1, No. 18) Another cable tool test on the Burning Springs anticline started in October, 1951, with the lower Silurian sands as a primary objective. This well was drilled by the United Fuel Gas Company, one of the Columbia System subsidiaries, and is located about 12 miles south of the Hope deep test at Sand Hill. The well is in Wirt County, West Virginia, 5 miles northeast of Elizabeth. United Fuel, like the Hope, started with an extra large hole and set 10¾ in. pipe on the Onondaga line. A substantial volume of salt water was found in the Oriskany sand and the well was shut down in the spring of 1952.

In 1953 a rotary rig was moved into the location and the well was deepened to the Medina. At 6120 ft it encountered a major thrust fault and repeated a large part of the upper and middle Silurian. The Medina sand was cored using diamond bits and well was abandoned with tools left in the hole at 8206, 161 ft in the sand, not deeming advisable to attempt a lengthy fishing job in order to test the remainder of the lower Silurian.

Glaros & Katros—No. 1 Kyle Morse (Fig. 1, No. 20) In Chautauqua County, New York, about eight miles southwest of Jamestown, Glaros & Katros started a Medina sand test in 1954 which found a small amount of gas in that horizon and was then drilled deeper to the sub-Trenton. This well found a small volume of gas in sandstone which probably correlates with the Gatesburg of upper Cambrian. A small amount of salt water was encountered in dolomite below the gas and the operators are now preparing to cement a string of 5-in. casing in the well. They plan to perforate and hydrafrac both the Cambrian and Medina gas zones. Present total depth is 7100 ft.

Problems for Sub-Devonian Wells

No review of the foregoing operations would be complete without some discussion of Appalachian drilling problems and their effect on sub-Devonian exploration. Cable tool wells in particular have been hampered by the exceedingly hard sandstones of the lower Silurian and upper Ordovician. These formations attain great thicknesses, especially in the two eastern provinces, and are particularly difficult to drill where steeply dipping or severely fractured. The history of many of the test wells described is one of crooked hole trouble, slow progress, and frequent, prolonged fishing jobs. Perhaps the wildcatter's solution will be a combination of cable tools and rotary equipment, an arrangement which has worked successfully on three of the holes described in this article.

At first glance cable tools seem to have a distinct economic advantage, particularly on wells shallower than 6000 ft in depth. Their per diem operating costs are less than one-sixth that of rotary whereas their penetration rates probably average at least one-third those achieved by rotary.

The main difficulty which plagues deep cable tools tests is the frequency

of serious fishing jobs which often constitute a large percentage of the total drilling time. This excessive time factor cannot be ignored and, in addition, there is the ever-present uncertainty of completion since many cable tool holes are lost before reaching their original objectives.

Consideration of the above suggests that rotary equipment is desirable for sub-Devonian wildcats where the projected depth is in excess of 6000 ft and, under some circumstances may be recommended for wells of lesser depth. During the past two years, the increasing use of rotaries in the Leidy and Benezette Oriskany gas fields has resulted in remarkable improvements in the efficiency of the method and sharp reduction in operating costs. Future deep exploratory ventures in the Appalachian area although expensive will benefit from the experience and knowledge gained in drilling wells such as those listed herein.

Outlook

Although the deep tests described in this review have not resulted in any commercial discoveries, the outlook cannot be considered discouraging for the Appalachian Basin is a vast sedimentary trough and, insofar as the sub-Devonian is concerned, relatively unexplored.

The data obtained from the drilling of these wells and their predecessors will ultimately prove useful and valuable in future exploration. They will doubtless throw light on such problems as formation pinchouts and facies changes which may be the principal key to unlocking future production from Silurian and deeper horizons. However, one immediate fact of outstanding importance is the persistent occurrence of porous zones in the dolomites of upper Cambrian age and the possibility of additional reservoirs in the lower Ordovician. The general characteristics of these rocks on the outcrop and in well cuttings show close similarity to those of the Ellenberger and Arbuckle formations of the Mid-Continent, and there is every indication that these Appalachian dolomites have a good chance to produce if tapped on closures or stratigraphic traps of suitable magnitude. This seems to be particularly true of the western Allegheny Plateau area where wells like the Eichenberg have demonstrated the presence of significant quantities of oil and gas.

It is probable that favorable Ordovician and Cambrian reservoir conditions exist in the two eastern provinces, but fewer wells have penetrated those formations under optimum geological circumstances. The currently drilling Hope Natural Gas Company deep test in Wood County, West Virginia, will undoubtedly yield considerable information on the possibilities of these formations.

East of the structural front such formations can be reached at relatively shallow depths on large prominent closures, but folds which have been so deeply breached by erosion as to expose Ordovician limestones and dolomites cannot be considered very promising. The Hogue, Walizer, and Snyder wells suggest that, where such protective cover as the Reedsville shale is lacking, surface waters have had an opportunity to permeate the fracture systems to great depths and the preservation of commercial quantities of hydrocarbons is not likely under such conditions.

Structures like Schellsburg, on which the Miller well was drilled, have ample sedimentary cover and deserve further testing. Unfortunately it was impossible to carry the Miller No. 1 through the lower Ordovician dolomites and into the Gatesburg. The Reno Solomon No. 1, now drilling in Reedsville, is on another attractive structure and should be watched.

Moving up to the limestones of the middle Ordovician it cannot be said that these formations have as yet shown any great promise. In the northern part of the area covered in this review they are quite shaley and apparently devoid of reservoir-type rocks. Conceivably they could produce from fracture porosity or reefs but no convincing evidence exists that such conditions occur on any important scale. To the south, in West Virginia, they remain a potential objective since they are reported to be petroliferous on the outcrop in northwestern Virginia and produce crude oil of Pennsylvania Grade in southwestern Virginia and in Tennessee. Additional facies studies such as those by Kay[1] and Prouty[1] could prove highly profitable if extended to the subsurface by deep well samples.

The Oswego sand of upper Ordovician has as yet failed to show porosity in the sub-surface although in places on the outcrop it appears to be a potential reservoir rock. Most favorable area for exploration is believed to be in western Pennsylvania where it pinches out to the west and where insufficient wells have been drilled to explore its possibilities.

The Medina sand (also called Tuscarora and Clinton) of lower Silurian is almost universally present but porosity in it is rare. In the Miller well it carried salt water, probably from fractures, and in the Shaw and United Fuel Gas Fee wells had interesting gas shows. This zone cannot be ignored in future deep drilling even though its record in the deeper portions of the Basin has thus far been poor.

The Williamsport of middle Silurian produced gas in the Thornbury well and has commercial possibilities in West Virginia although, like the Medina, it can be considered only as a secondary objective in most areas.

Acknowledgments

Most of the data from which this review was compiled came from the files of the South Penn Oil Company and its subsidiary, the South Penn Natural Gas Company. Appreciation is expressed for their permission to release and publish this information. The reports on the individual drilling wells were obtained through the courtesy and mutual cooperation of most of the companies in the Appalachian area who, through scout checks and personal communications, have pooled a remarkable amount of geological and engineering data. General acknowledgment is therefore accorded those companies and individuals listed earlier in this article and many others who over the years have contributed the information necessary to its compilation.

References

1. Appalachian Basin Ordovician Symposium; August, 1948 Bulletin; American Association of Petroleum Geologists; Vol. 32, No. 8. ★

Calvert Drilling Company Formed by Merger

F. A. Calvert, Jr., president of Calvert Drilling, Inc., announced that Calvert Drilling Company, an Oklahoma corporation, and Calvert Exploration Company, a Delaware corporation, have been merged into Calvert Drilling, Inc., an Illinois corporation. Home office is in Olney, Illinois.

The company owns and operates twelve rotary drilling rigs, and production in Illinois, Indiana, Oklahoma, Colorado, and North Dakota. The Oklahoma area will continue under the management of H. K. "Tony" Calvert, with offices at 407 City National Building, Oklahoma City. Rocky Mountain area will continue under the management of Raymond B. Kelly, Jr., with offices at 2236 Mile High Center, Denver, Colorado. The Williston Basin area will be managed by James A. Burhans, with offices in the Professional Building, Bismarck, North Dakota.

Calvert also announces that Transportation Division, which formerly operated as partnership between the company and Noel Everett, has been purchased by Calvert Drilling, Inc., Noel Everett continuing as general manager.

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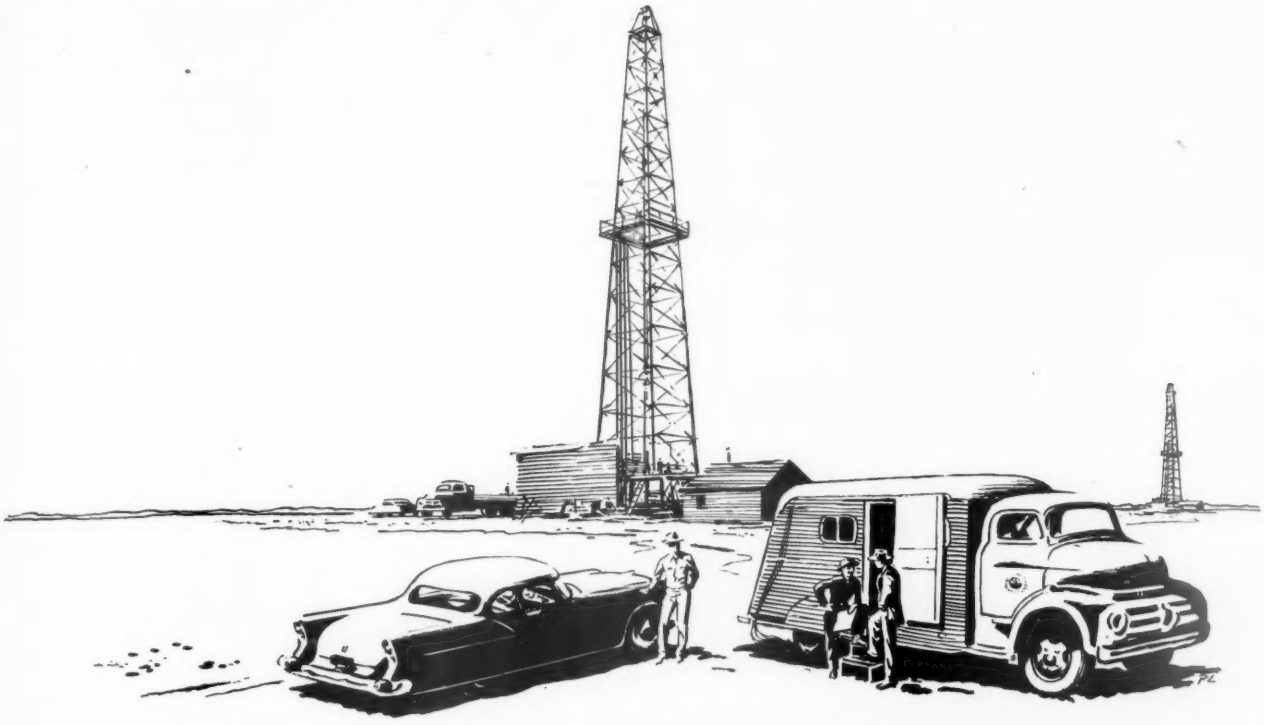

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Thomas J. Bono

DISCOVERY of the Leidy gas fields in Clinton County, Pennsylvania in 1952 and the Benezette field in 1953, emphasized the need for rapid well completions, in order to "get the jump" on offset drilling operations and prevent gas drainage from the leased properties.

Delta Drilling Company of Tyler, Texas, was the first contractor to be brought into the area with a rotary rig. Previously all the wells had been drilled by cable tool rigs, usually requiring some twelve months to complete a well.

Upon completion of the first rotary drilled well in Pennsylvania, other rotary drilling companies were contacted and their rigs brought up to the Pennsylvania gas fields. Delta had shown the local operators how quickly a hole could be completed with a modern rotary rig and a trained crew. While the cable tool men were setting up, the rotaries would be well on their way to the completion of a well.

Fryer and Hanson Drilling Company, Dallas, Texas, and C. J. Simpson Drilling Company, also of Dallas, were soon in the Pennsylvania gas field picture, each attempting to set new records with their rotaries.

Rotaries, however, were not without their problems. Operators soon found that they were faced with frequent lost circulation problems while drilling surface holes and unless they kept a close check on drilling weight, they were plagued with crooked holes.

Recalling how similar problems in West Texas and California had been solved by using air in place of fluid as a circulating medium, Delta decided to try this method on one of its wells. It was quickly shown that not only did air solve the lost circulation problem, but it also had many other advantages and other rotary drilling contractors quickly applied air drilling to their own operations.

EXCLUSIVE

Penetration Rates Improved

The first air-drilled rat hole, in the area, showed clearly the advantages gained by air drilling. This hole was drilled in 6 hours as compared to the 24 hours usually required with fluid. Cuttings up to one-half in. in diameter were discharged from the hole which was 8¾ in. in diameter and in hard sandstone. With subsequent improvements in techniques, such as using a greater volume of air, higher air pressures, larger manifold piping, and a larger standpipe to cut down back pressure, the rat hole drilling time has been lowered in at least one case to one-half hour. This was accomplished by the John Fox Drilling Company of Bradford, Pennsylvania, while drilling a wildcat well at Rockton, Pennsylvania.

In the initial rat hole and subsequently, the surface hole, 2 rotary vane type portable compressors of 600 cu ft per minute capacity each, or a total of 1200 cu ft per minute, with an operating pressure of 100 psi were used. The penetration rate, drilling the 12½-in. surface hole was only comparable to fluid, due primarily to air volume deficiency and insufficient air pressure. This surface hole test failed when excessive surface waters were encountered at 200 ft, and prevented additional drilling with air.

The subsequent surface hole test employing 3 rotary type portable air compressors with a total capacity of 1800 cu ft of air per minute at 100 lb per sq in. was drilled to 410 ft. At this point it again became necessary to revert to fluid.

Although the surface waters overcame the air at this depth, the decided increase in penetration rate was such that even with this limiting factor, the test was considered a success. On this well, it was particularly noted that drilling could continue as long as the entire amount of fluid seeping into the hole could be blown off along with the cuttings.

The next surface hole drilled, utilized three 600 cu ft, diesel driven, portable compressors, set for 200 psi operation. This was successfully drilled to the casing setting depth of 710 ft.

The penetration rate of 10 ft an hour was excellent by comparison with fluid drilling; the surface waters were blown

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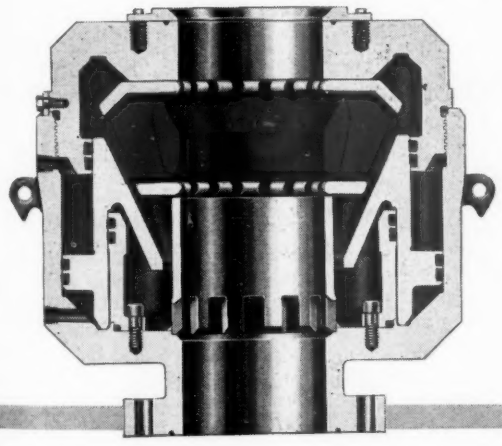

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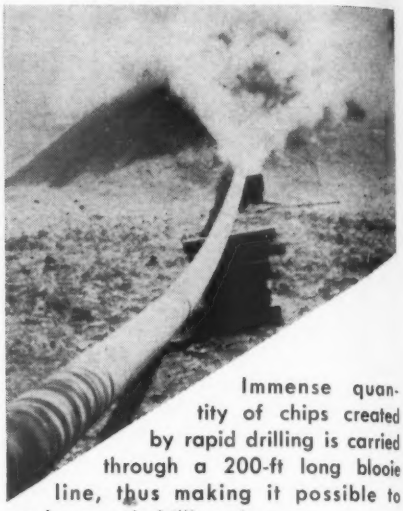
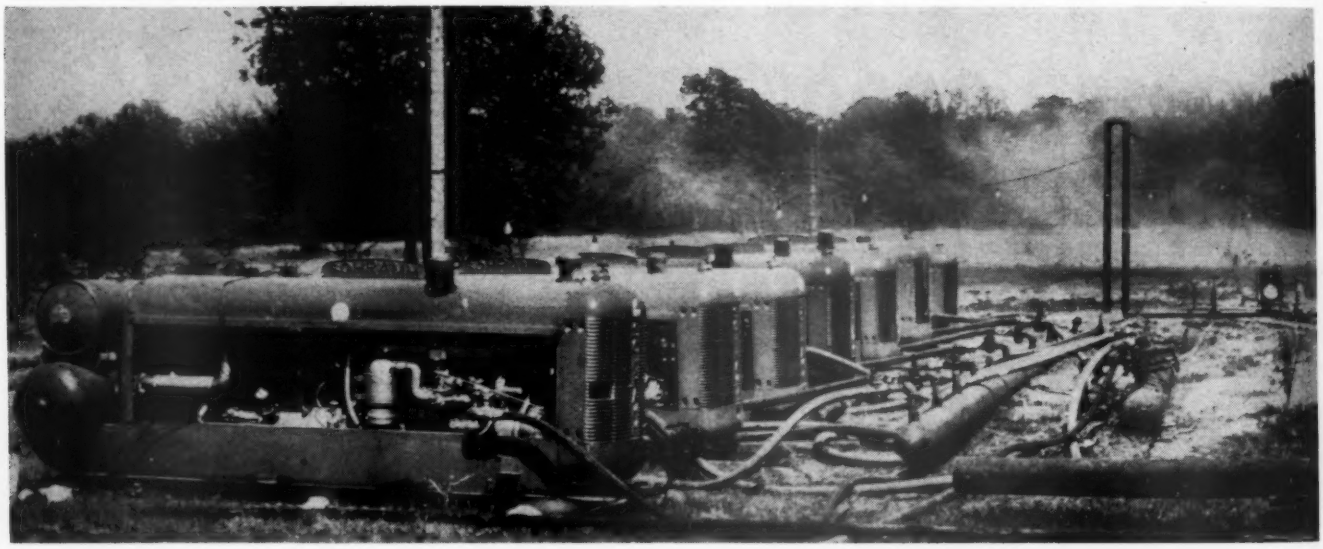


Immense quantity of chips created by rapid drilling is carried through a 200-ft long blooie line, thus making it possible to work around drilling rig.

Seven skidded 600-cfm compressors operating on natural gas are pumping into a manifold to furnish a high volume (4200 cfm) of compressed air in order to remove chips while drilling a deep well.



from the hole as fast as they kept flowing in and were removed along with the cuttings throughout the drilling period.

As the drilling crews have kept acquiring more and more air drilling "know how," most of the difficulties encountered not only have been adequately coped with, but also on many wells, the drilling time has been brought down from about 30 days using fluid, to less than 11 days using air.

Water Zones Air-drilled

It was very gratifying to operators to learn that surface waters could be discharged throughout the entire depth of the surface hole and increased penetration achieved at the same time with no fear of lost circulation. It was generally agreed that the higher air pressure (200 psi) is necessary to drill at 700 ft with fluid in hole. Once the fluid has been aerated and removed, pressure requirements for keeping the hole blown clean are much less. It was concluded that to drill a 12½-in. surface hole using 4½-in. drill pipe to 700 ft, a minimum of 2400 cfm of free air should be available in order to achieve optimum results.

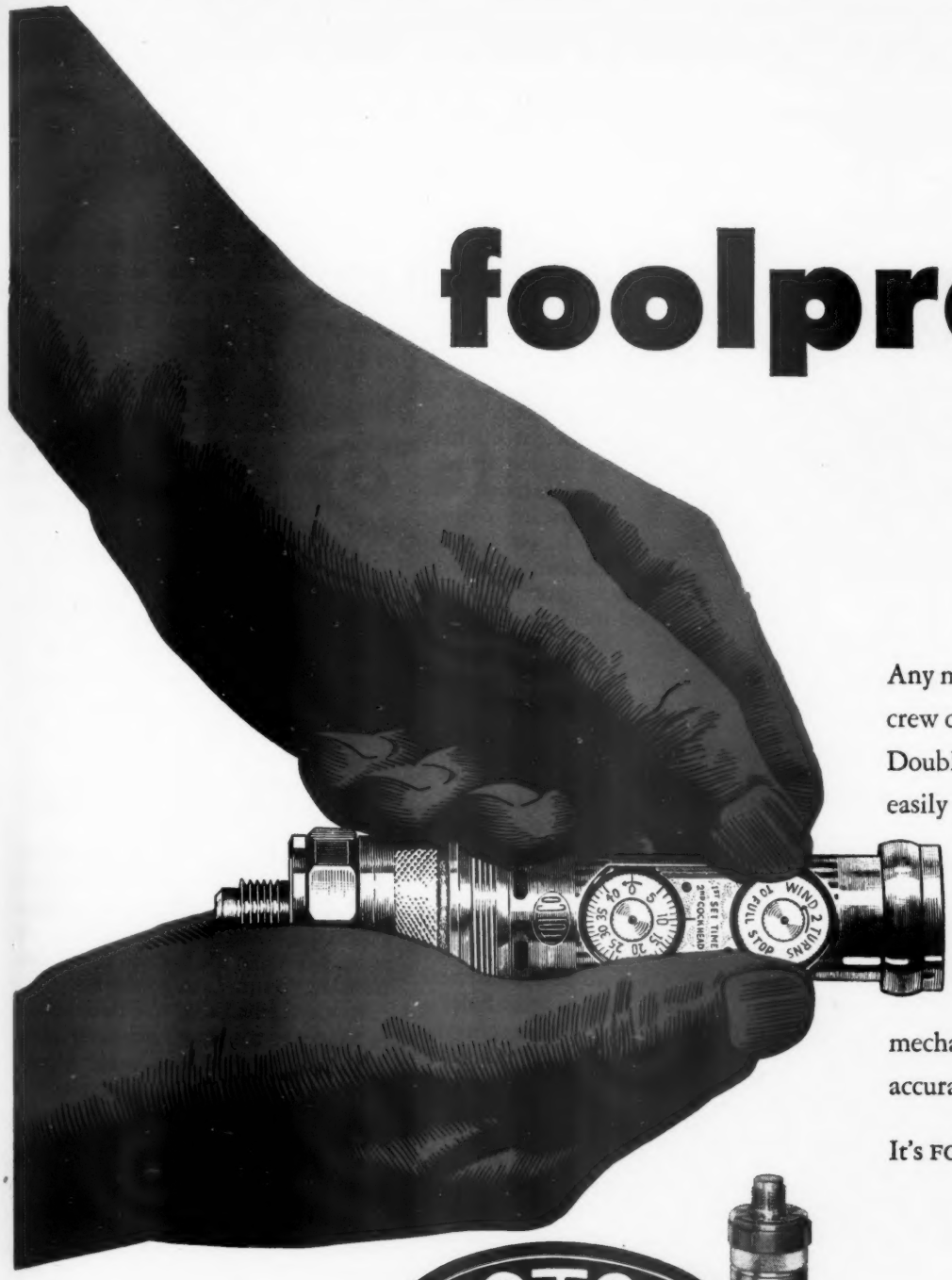
Where small amounts of water in the surface hole caused a "balling up" of the shales, additional water was added to the hole to reduce the gummy solids to liquids and thence blow them out by the air.

Air Used Under Surface

Drilling below the surface hole, from the very beginning, unquestionably indicated the advantages of air drilling over fluid drilling. Savings were quickly apparent in the increased rate of drilling. In fact, the drilling rate was more than doubled and bit life measurably increased. This meant fewer trips and fewer bits consumed per well.

The following table of comparison, prepared by Harold Magner, district manager for Delta Drilling at Bradford, shows six wells drilled in the same general area. Wells A. B, and C, were drilled with fluid and wells D, E, and F were drilled with air. The table clearly shows the savings effected in time and cost, drilling with air.

foolproof



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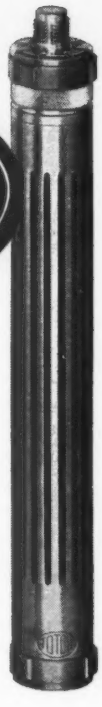

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Fluid air comparison of representative wells drilling in Elk County, Penn.

Well	Number 8¼" bits	Drilling hours	Feet drilled	Avg. ft per bit	Rate pent. ft/hr.
Fluid drilled					
A.....	26	358½	5454	210	15.2
B.....	32	320¼	5503	172	17.2
C.....	39	347½	5271	135	15.2
Avg. fluid..	32	342	5409	169	15.8
Air drilled					
D.....	33	230	6415	194	27.9
E.....	28	177½	6391	228	36.0
F.....	19	160	5301	279	33.0
Avg. air...	27	189	6036	223	31.9

The other rotary drilling contractors in the area were quick in converting their drilling operations to air and they now report savings far greater than those indicated by the above table. The C. J. Simpson, Fox, and Keta Drilling Companies have reported air drilling has whittled as many as 20 days from the completion of each well at an estimated savings of $1,000.00 for each day eliminated.

New Techniques Developed

Of necessity, new techniques were developed and incorporated in the drilling procedure. It was soon learned that the rig was under greater stress, due to the movement of the pipe in a dry hole. Eight lines were strung instead of the usual six and this is now standard. Checks have been made of the drill pipe and tool joint wear, but surprisingly enough, no appreciable reduction in size has been noted. Perhaps this can be attributed to the prevalence of limes and shales in the formations drilled and the general absence of sandstone.

It was also learned that a nearly perfect gage hole was drilled. Caliper surveys reflected this even in the softer formations. Some reaming has been required where bits were run out of gage.

With fluid, 15 drill collars were normally employed and it was thought that an increase in this number would result in better penetration. With air, it was ascertained that the 15 collars were more than enough. Little difference was noted in penetration rates between the range of 20,000 and 30,000 lb on the bit.

It was also soon learned that the air-drilled hole tended to deviate in certain formations which had hard and soft zones intermittently. This situation has been controlled by taking off the drill collars, using a four cone rock bit, reducing the weight on the bottom and increasing rotation speed.

Fishing and stuck drill pipe have been adequately and satisfactorily coped with on air-drilled jobs. The main cause of the latter has been due to the carelessness of permitting cuttings to fall back in around the pipe and the bit at the bottom of the hole by failure to blow the hole prior to adding a new joint.

It was found that if the air was turned off immediately when the kelly was drilled down, the cuttings enroute to the top of the hole would fall back and settle around the joints and the bit and would cause the drill pipe to jam when being pulled out of the hole. On occasions, several hours were required to work the pipe sufficiently to allow the air to loosen the cuttings in the tight places. There were no indications of sloughing formations in these holes.

On one occasion a small amount of water was encountered below the surface string. Unsuccessful attempts were made to blow this down and dry up the formation. A satisfactory squeeze job was performed, however, and the well was drilled to its total depth with air after the squeeze.

In one particular shale formation, the penetration rates were so great that the compressor volume and pressure were not sufficient to keep the hole completely blown out. It is not uncommon to require 15 minutes or less to drill 30 ft and require an additional 15 minutes to blow the hole clean.

On three different occasions, gas blowouts were encountered in shale pockets above the pay horizon. These are normally quite damaging to cable tool operations but were of little consequence in the air-drilling operation.

This experience reduced the widespread fear of air-gas explosive mixtures and their accompanying disastrous possibilities.

Hard formation, short-toothed bits have shown the best results, probably due to the smaller cuttings produced which can be blown from the hole easier and quicker. Also, these bits hold gage better and make more footage.

Return Velocity Important

It is the general opinion of those people experienced in air drilling that a return velocity of 3000 ft per minute in the annulus is necessary for efficient penetration rates.

Further experience and research will bear out the validity of this opinion but it would appear that a maximum return velocity will be reached at a point where the additional cost of added volumes of air will outweigh any improved penetration.

It was noted that the 3000 ft per minute velocity keeps the bit entirely free from the cuttings. This appears to be one of the biggest assets of air over fluid. By comparison, a return velocity of 180 ft per minute for fluid is considered quite good.

It was very definitely felt that the higher air pressures had a great influence on the ultimate completion of a hole. Additional pressure is particularly advantageous where waters might be encountered, in fishing jobs, where the pipe is stuck and in soft digging, where the increased pressure assists in lifting larger volumes of cuttings from the hole.

Deeper drilling with air should require greater pressures at the compressors, in order to offset the pressure losses due to the friction of the air passing through the various restrictions from the compressors to the bit.

It was learned that hook-ups should be made in a manner so as to avoid flow restrictions. These cause a pressure build-up at the compressors and result in volume decrease, fuel increase, and more rapid wear of the compressors.

A rotating drilling head was used on top of the blowout preventer to eliminate dust around the rig. Cuttings were removed through a 7-in. line and discharged some 200 to 300 ft away. Since these locations have been in remote areas, the dust has not been considered a nuisance as such, but if drilling is done in a populated area, some means must be found to decrease the amount of dust blown into the air.

At the present time most of the compressor installations in this field consist of three 600 cfm portable compressors powered by either diesel or natural gas engines. The present trend has been toward the installation of a stationary unit, capable of producing this same volume with a maximum pressure of 200 psi.

This permanent unit is pulled from the pump drive without alteration to the motor speed or compounding system and allows for the interchange of compressors and pumps. * * *

The Author

T. J. Bono is an air drilling specialist for Shramm, Inc., West Chester, Pennsylvania. Presently applying compresed air to the drilling of oil and gas wells, he has specialized in experimental and development work in drilling blast holes in mines with tungsten carbide bits and developed long hole drilling with sectional steels.

He is a graduate of the University of California, Los Angeles, where he also did post graduate work. He spent two years in the Navy.

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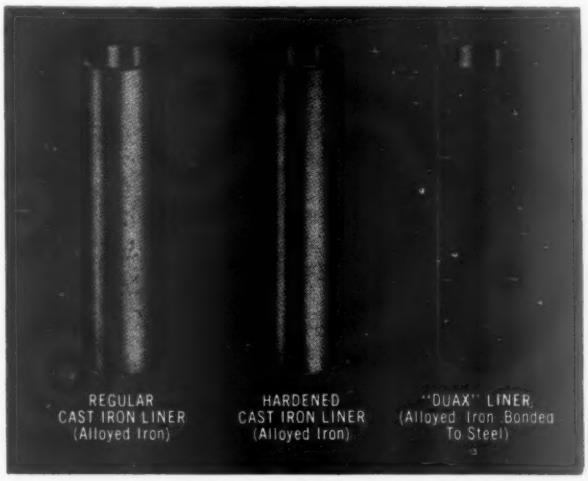

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Problems of the Deep Appalachian Basin

Better coordination of available information needed for development of program to utilize the resources of the six-state area.

H. P. Woodward

THE deep Appalachian basin is an area where the pooling of all geologic data is likely to have great practical value. Much useful information exists in company files and unpublished notebooks that is already assembled and paid for and should be made available to the profession as a whole. I urge that some effort be made to collect, classify and distribute this unpublished information to those closely concerned, for it seems certain that advantages will accrue to everyone operating the oil and gas industry in the region.

I concluded an API paper* with the above and now wish to develop this proposal, not by explaining how such a joint project should be organized, but by suggesting particular problems that require solution. The topics selected broadly affect the entire structural basin that occupies parts of the Virginias, Pennsylvania, Maryland, New York, eastern Ohio and Kentucky. For some of the issues raised I shall suggest possible answers; for others I have only the bare question to present you at this time.

We might start with this significant query:

1. **Are the total productive and storage resources of this important basin already catalogued and fully known?**

If you agree to this, then our only concern is the wise conservation of known reserves so as to guard them safely while they wane to extinction. If your answer is negative, as I believe it must be, then the problem should be rephrased as follows:

2. **Since it is not believed that the capacity of the Appalachian basin has been exhausted or its production and storage possibilities fully explored, how should we go about the further discovery and utilization of resources now unknown as cheaply, wisely, promptly and usefully as possible? In short, what, for the basin as a whole, is the best possible geologic program for its continued and ultimate development?**

*"Some Properties of the Deep Appalachian Basin," American Petroleum Institute Division of Production, White Sulphur Springs, West Virginia, June 17-19, 1954.

This question, of course, extends far beyond the limited subjects on which I am competent to speak, and I shall venture observations only in a geologic vein. Perhaps a third query will focus your attention on what I hope to emphasize:

3. **What are some of the unsolved geologic problems that affect the further development and exploration of the entire basin, and how should these be attacked?**

I propose to explore four questions; one is historical, one structural, one stratigraphic, and one is unspecific. All stand on a very broad base, but each can be pointed toward issues that concern us all. They are similar in that they cannot readily be answered save by the concerted efforts of many persons.

If these questions need further introduction, it is only to remind you how little we really know about the Appalachian country and its history. It is easy to say that the familiar rocks of the basin were mostly deposited in what is called a geosyncline, to the east of which stood highlands of some unknown sort; that shortly before Triassic time, high mountains were developed during the Appalachian Revolution; and that in some fashion the former sediments were sliced by faults and crumpled into folds, the roots of which —after long subsequent erosion—now form the bedrock of the Appalachian Mountains, the Alleghany Plateau and the Eastern Interior. We can all venture a little beyond this simple outline, but even the most expert and knowledgable geologist quickly reaches the limits of his exact information.

We know, too, that sometime and somehow organic material of uncertain sort was transformed into petroleum and natural gas in processes of which we are not yet sure. Later these hydrocarbons moved to places where we now find them, but we do not know quite how, when, or how far they migrated. Sometimes we now find them in upward structures, sometimes along old shore zones, occasionally in sand bars. Often we don't find them, and that is painful and expensive. It is quite plain while we have adequate knowledge of how to drill for them, we still do not know exactly where to look or what governs their location or preservation.

THE BASEMENT FLOOR

Let us pass over some fundamental questions about the origin, emplacement, and migration of oil and gas; about the nature of the geosyncline and what lay east of it; and start with an historical question that you may have lately overlooked:

1. **What was the character of the floor upon which Appalachian sediments were deposited, and how and how long did its ancient grain determine subsequent events?**

It is well known that the gap between Paleozoic sediments and the Pre-Cambrian outranks in magnitude any subsequent structural or stratigraphic break. It is likewise clear that this unconformity attests the intense deformation, uplift and erosion of all older materials before Cambrian sands first sank in the Paleozoic sea. The complexity of the basement was fully established before

The Author

Herbert P. Woodward is a graduate of the University of Rochester. At Columbia University he was awarded the degrees of M.A. and Ph.D. in geology.

Dr. Woodward has taught geology at Columbia University, Barnard College, Hunter College, and the University of West Virginia. Since 1946 he has been dean of the Newark College of Arts and Sciences of Rutgers, the state university of New Jersey.

He has worked for the New York State Geological Survey; the Pure Oil Company in Texas; the American Museum of Natural History; Virginia and West Virginia Geological Surveys; Shell Oil Company; and since then for various companies operating in the Appalachian basin. He is a fellow of the Geological Society of America and the American Association for the Advancement of Science; a member of AAPG, and an honorary life member of the Appalachian Geological Society.

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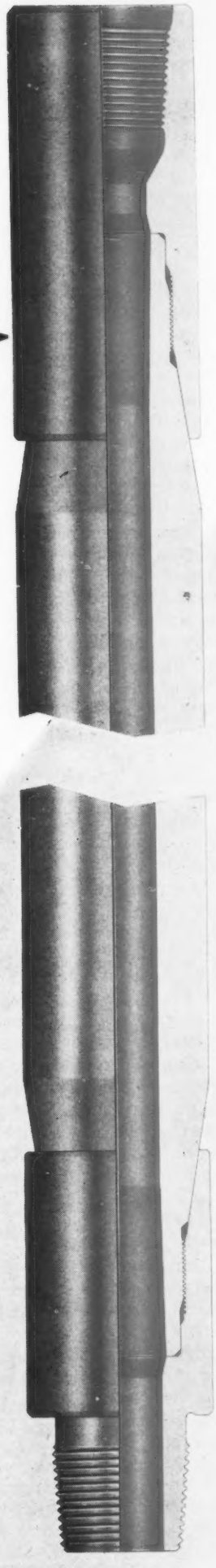

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any younger geologic history, but it cannot have avoided a controlling effect on many later events.

There are several things we need to know about this ancient floor. What was its direction of grain? Was it completely flat, or were there ridges on its surface now buried below later sediments? How did it behave during subsequent folding and did it control some of that deformation?

Seeking to uncover the true structure of the crystalline complex, one must use two lines of approach, first the ancient geography of the Cambrian, second, the present foliation of Pre-Cambrian exposures. One must assume the geographic conditions at the close of the Pre-Cambrian bore at least as close relation to the bedrock of that day as modern topography bears to the present subsurface. If this is correct, then Cambrian geography should reasonably reflect still older structures.

Almost immediately we encounter a problem, for to develop the true position of early Cambrian geography, we must completely eliminate all results of later deformation and orogeny that may have moved land and sea elements far from their original orientation through crumpling, faulting, and westward thrusting. This means that we cannot use a present-day base on which to plot our data, but must improvise a new map that will restore our control points to their original locations.

Marshall Kay has described such a map as "palinspastic," and he has attempted one or two examples for the Ordovician system. I believe we need several such maps for the entire Appalachian basin computed for different time epochs, both for the proper interpretation of ancient geography and also for the accurate plotting of isopach lines. Let me suggest such a project as likely to be rewarding.

Returning to the strike of Cambrian geography, I think whatever its former shape that the great geosyncline wherein Paleozoic sediments came to rest had a course that was nearly north-south in the central Appalachians, and I believe the grain of Cambrian land bodies likewise followed a north-south trend.

The matter of proper orientation also plagues us in studying present exposures of the basement itself, for these ancient rocks have passed through many later epochs of metamorphism and intrusion. Something of their probable north-south grain, however, is manifest in the Piedmont region, where there is a divergence of as much as 20° between the strike of Paleozoic and Pre-Cambrian structures. On the other hand, certain elements of Pre-Cambrian architecture in southern Canada strike east-west, but this condition seems not to extend into the area of our concern.

If I am correct that Pre-Cambrian geography and rock foliation once extended north-south in this region, then we can suspect any present north-south structure of being partly controlled by the basement surface; and since I cannot regard that surface as having been completely flat or level, I believe we must also be on the lookout for undiscovered structures bearing this ancient trend—structures that may now be completely concealed.

It is clear from deep drilling and seismic studies that the present basement surface is warped in harmony with major sedimentary folds, as the ancient crystallines not only transmitted the deforming pressures upward, but became warped themselves in the same process. Deep-seated folds such as these doubtless first followed pre-determined lines so far as the deforming pressure would allow, and the strike of the basement structure may well have influenced the very direction of movement. Thus I believe that most early deformation faithfully mirrored the ancient grain of the structural floor, including specifically the north-south trend of post-Ordovician or Taconic folding; the early formation and uplift of the Cincinnati anticline; and certain zones of late Paleozoic folding—all of which inherited this "posthumous" trend.

Burning Springs-Volcano anticline has a north-south axis unlike most West Virginian anticlines, and although it is much smaller in size it closely parallels the Cincinnati arch in the direction of its strike. Was this structure directly controlled by the buried basement, at least when it was first fashioned, and does it therefore differ in character from nearby structures? If so, and it is a reasonable notion, should not its deep prospecting be differently pursued than on other folds which fit more familiar patterns?

For example: If this anticline was raised very early by basement architecture could Taconic folding have made it high enough ground during the Silurian to provide facies changes and stratigraphic traps—not on top of the structure—but along its eastern flank? Could the same thing be true for the Oriskany, with potential production being situated off-structure, rather than on the arch? I don't know if either suggestion is valid, but the ancient basement may need your study.

Nor is this the only example. There are other north-south structures, obvious or concealed, that probably reveal control by the basement surface. As a case in point, it has been suggested that the "no-Oriskany" zone in northwestern Pennsylvania coincides with a still older north-south arch of pre-Oriskany age, and I know of other places where poorly defined but probable north-south structures peer through younger sediments and later folds. What do we know about these, and don't they suggest a substantial problem for study? Let me rephrase this point so it will not get lost: As it is unreasonable that the Pre-Cambrian floor was perfectly flat when the first sediments reached it, are there undiscovered folds over buried ridges that affected early but not later sediments, and could these be favorable sites for early-stage accumulations of oil or gas?

Finally, is not a very thorough knowledge of the character and grain of the buried Pre-Cambrian essential to an accurate interpretation of magnetic, gravity, and seismic exploration of overlying sediments?

My purpose in unearthing the ancient crystalline basement is not to display my own ignorance of it, although I have done just that, but rather to highlight it as a subject that ought to be given careful thought. Perhaps these remarks will redirect your attention to its considerable importance and to the value of pooling every bit of information that anyone knows concerning it.

EARLY DEFORMATION

Let's try a structural question and explore some of its angles.

2. Was all Appalachian folding simultaneous, and, if not, what sequence of movement was involved; when and where did earliest deformation occur?

It is well known that in the New England-Maritime provinces of northeastern North America, Paleozoic rocks were deeply involved in at least three separate orogenies: the Taconic disturbance, generally described as post-Ordovician; the Acadian disturbance of late Devonian time; and the main Appalachian revolution at the close of the Paleozoic. Did all of these orogenies, or others, also affect the Appalachian basin?

Results of the Taconic disturbance are best seen in the narrow north-south belt that lies east of the Hudson River and Lake Champlain. Rocks of this region exhibit effects of extreme compression and show much intimate deformation. Their intense folding and sheet-thrusting represent substantial shortening of the earth's crust in an east-west direction, the pressure having been directed westward against the staunch Adirondack dome which formed a coherent and unyielding buttress. Mainly that country east of the Hudson and south of the St. Lawrence

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was affected by Taconic unrest, yet an angular unconformity can be traced under basal Silurian sands from the Hudson River through northern New Jersey at least as far south and west as Harrisburg, Pennsylvania. Does this suggest that the older rocks of the northeastern part of the basin have been too greatly disturbed to qualify as potential reservoirs?

Much igneous material changed position in New England at this time. Late Ordovician lavas occur in eastern Virginia, eastern Pennsylvania, southern Quebec and northeastern New York, Ordovician metabentonite was blown widely over the entire Appalachian country. In short, this was a time of much crustal movement, and I think it important to determine whether or not there were other effects in the basin proper. The strike of most Taconic folding holds a north-south pattern probably inherited from the Pre-Cambrian basement then not far below ground. Except in a few localities, Taconic and later Paleozoic folding widely diverge in trend and strike.

If nothing else, we are already concerned with two of what I would call Taconic foreland folds—the Cincinnati anticline itself, and the smaller but equally important Adirondack axis. Both of these arches gained their first upward thrusts at this general time; both hold the old north-south Pre-Cambrian strike, and both affected materially the nature and distribution of contemporary and later sedimentation.

Have we found all of the Taconic foreland folds? Can there be other perhaps smaller folds, formed at this general time, that have so far escaped our notice? We have pretty well explored the Cincinnati anticline, but what do we know about the Adirondack arch? In connection with the latter, there are some very penetrating unanswered questions. For example: Are there reservoir possibilities on the arch itself? Is there a major producing area hidden to the east of the arch in eastern Pennsylvania and southeastern New York? Did stratigraphic conditions for marginal shoaling or facies change also occur on the east flank of this axis? It is generally stated that the Adirondack arch continued southwestward before the Devonian so as to merge with the Tazewell axis of southwest Virginia. On the other hand, during Oriskany time, the Adirondack arch seems to have extended nearly due south to join with the Blue Ridge anticlinorium that ends in South Mountain below Harrisburg. How are these two views reconciled?

Some of the matters relating to late Ordovician folding have only recently been appreciated, and the amount of study that remains to be done is impressive. In view of the certain relation between early deformation and possible production from the base of the rock column, I am sure we must carefully review the extent of Ordovician folding before we can satisfactorily appraise the deep potentials of the older rocks.

Take the matter of middle and late Devonian movement. The vigorous pre-Mississippian deformation of the Acadian region left little obvious trace in the main Appalachian basin, save in the thick clastic sediments which its uplifted highlands contributed to the top of the Devonian rock section. But the disturbance was intense in New England, and granites of late Devonian age were intruded in the West Point region of New York State and the Piedmont area of Virginia and the Carolinas. Perhaps the peculiar Flynn Creek structure of Jackson County, northern Tennessee, was a late Devonian explosive crater filled with Chattanooga shale.

But was there no Devonian uplift or deformation in the main Appalachian region? It is my belief that the Oriskany sandstone is thinned on such major structures as the Warfield anticline, parts of the Chestnut Ridge anticline, and perhaps along some of the other large folds. I suspect there are concealed structures near Marietta, Ohio, that are not everywhere reflected in the early or middle Mississippian rocks. I am not yet convinced that we can distinguish between Acadian and the later Appalachian folding in southeastern New York and eastern Pennsylvania, and I believe we should immediately assemble all of our information to see what changes may have been produced at this general time.

Suppose I am right that accumulations of oil and gas were emplaced very early, so that there was already gas in the Silurian before the Oriskany was deposited, and Oriskany gas before the Berea was deposited. Would not the present sites of such accumulations have been seriously affected by Devonian folding, and shouldn't we know where and how the latter occurred?

Perhaps the most critical question regarding Devonian deformation is whether it was merely the prelude to subsequent Appalachian folding and followed the strike of the later folds, or whether it was a distant echo of the Acadian revolution and created a fold pattern, now concealed, that is quite separate from that of the later crumpling. If the latter should be true, then there may be belts of Oriskany thinning, or actual facies change, that do not precisely follow the lines of familiar structures, in which case Oriskany exploration in those areas need not coincide with the direction of surface folding. As an aside, let me remark that I hope we will not continue to place greater trust in the anticlinal theory than we do on stratigraphic and other non-surface-visible phenomena, for it is still perfectly clear that most exploratory wells in this basin are drilled primarily on the strength of surface indications. And this is no special plug for the seismologist.

Regarding the main Appalachian deformation with which we are most familiar, there are innumerable questions that are still unanswered. Here are two new ones: It is generally assumed that the late folding required a westward direction of pressure; but how do you reconcile the nearly east-west structures of northern Pennsylvania and southern New York with such a westward thrust? Also, what happens to the big Appalachian folds east or north of the Susquehanna River? On both of these matters I have some rather surprising theories which bear, I am convinced, on the further development of the basin; but I am not yet sure enough of the facts to discuss my views at this time.

Hence, let me ask you a more simple and practical question: Assume you have located a clear-cut surface-visible Appalachian-type anticline in exposed Catskill beds, and you want to drill it to the Oriskany or to the Silurian.

Research to Seek Unclaimed Oil

Dr. Alfred Chatenever, engineer with the Research Institute at The University of Oklahoma, has received a $9,000 grant from the American Petroleum Institute to continue research that may pave the way for new techniques that will allow the reclamation of millions of dollars worth of oil.

In 1949 Dr. Chatenever launched his studies of the behavior of fluids in porous media to discover what actually goes on inside oil producing strata. Using a microscope and ingenuity, Dr. Chatenever managed to get such a look. Then he made a motion picture so others could study the problem, too.

He found that about 50 per cent of the oil in a reservoir is reclaimed.

In his new studies Dr. Chatenever and API hope to enlist the best aid of the entire industry to reclaim that other 50 per cent of oil.

Oklahoma University's motion picture unit collaborated on the film and sound track of the movie. Chatenever acted as narrator.

The new $9,000 award is a publication grant. First project will be a brochure containing highlights of research work with color photographs. Second phase will consist of a comprehensive paper, and the final step will be another sound-color movie showing fluid behavior in porous rock.

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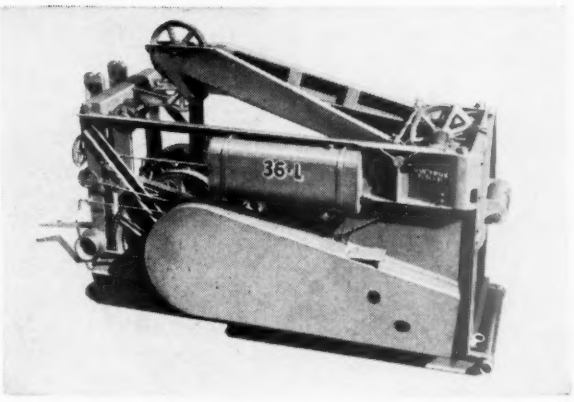

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Again I have not meant to raise irrelevant questions or to distract your interest from the immediate production of oil and gas, but I strongly suspect we are all extremely ignorant about the character, magnitude, timing and mechanics of the folding of the rocks from which our production comes; I am firmly of the belief that this opens up a broad field that badly needs attention and cooperative study from as many different sources as possible. Not long ago I wrote some of this to a good friend who has a high position in a company operating in this region. He replied very courteously, saying: "Most of us do not have much time to devote to scientific geology. We rely upon men of your stature for our basic general geology, working as you do in the field of pure science and spending many years on research and writing reports."

This is a fine and complimentary answer, but it needs a reply. Every geologist in his company as well as each of you knows some critical item of geologic information that nobody else knows, and the man of pure science will find these out only if he has the right connections or is unusually lucky. If all such bits of information could be made available, perhaps the pure scientist would be better able to attack these difficult and evasive problems by his usually unsponsored research.

To give the other side, I must remark about another letter. Many years ago I did some work for a company and wrote a report no copy of which I was permitted to keep. Ten years later I wrote to inquire if I could now have a copy of my own report. There was a very courteous reply which said in part: "We are sure you will be pleased to know that your very fine report is still held in the highest regard, but you will understand that we find it impossible to release a copy to you." Perhaps it is true that the kind of cooperative enterprise I envisage is impracticable, but I certainly would like to see it tried.

STRATIGRAPHIC QUESTIONS

I shall next propose a third major question, this time in a stratigraphic vein:

3. Do we yet have enough geologic knowledge about even the best known rock formations to plan adequately their full exploration and exploitation?

Here my answer is firmly **NO,** for I am confident that there is no living person who knows enough about any given formation in the Appalachian basin to answer one-half of the important questions that you can think up on a moment's notice—questions that affect the business we are all concerned with, namely, how best to develop this Appalachian country. I do not say if we pooled our data that we would have all the answers, but I am sure that the consolidated information would be more useful than any of its present component parts.

Rolled up in my office at Newark is an isopach map of the Oriskany over which I have pored for many serious hours. Doubtless ten blocks away, George Grow has an analogous Oriskany map in his office, also in Newark, New Jersey. There are probably half a dozen similar maps in New York City and in Pittsburgh, another half dozen in Charleston, at least one at Penn State, some at Columbus, probably a few at Houston, some at Bradford, another at Morgantown—and I need no more to make my point. Each of these maps differs somewhat from each of the others, for they were all individually and painstakingly prepared.

They are probably all on different scales; they do not all use the same control nor apply the same thickness figures for the same wells, perhaps mine is the only one that attempts to flatten out the folds and show geographic relations as they might have been during Oriskany time. But my point is this: If we could somehow coordinate and assemble all of this known information on a single map available to everyone, wouldn't the end result be beneficial?

Regardless of the source of the information, it seems to me we ought to know more about the Oriskany right now. Are there really two Oriskany sandstones, an upper and a lower member, with different fossils, different areas of distribution and different producing and storage potentials? What about Oriskany porosity? Is there gas in the Oriskany where it is porous or is it porous only where there is or was gas? How about the Oriskany east of the Adirondack arch? Is it present there with adequate porosity and should we not test to find out? How do you account for the crescentic distribution of Oriskany production that curves from the Summit pool past Terra Alta, Oakland, Canaan Valley and Bergton? Can there be facies changes or porosity patterns that have nothing to do with structural folds, so that areas not of upward structure might possibly produce?

I'm wondering also about some of the older rocks. How about the western feather edge of the Oswego sandstone where it grades into shale? Do we know accurately where this margin lies and has it been drilled? What about structural porosity in the Trenton, perhaps on one of those buried folds we suggested earlier? Or porosity resulting from exposure and erosion of the Beekmantown surface which was at ground level during the Mid-Ordovician. How about Cambrian sands? How far west do they go and do they have adequate porosity? Where were the original axes of deposition in the various epochs of sedimentation, and how do these concord with the main structural axis of the basin as a whole and with individual folds?

These are not idle questions, nor are they entirely unanswerable. On some of them various authors including myself have already stated our views, and I think each of you can give a reasonable answer to parts of them. But these are some of the things that I think we must know thoroughly to bring the full possibilities of this Appalachian country into proper production. I am sure that you can add a hundred more questions easily as important as these few suggested here, and perhaps the first step in their solution is to list the matters for which we need answers.

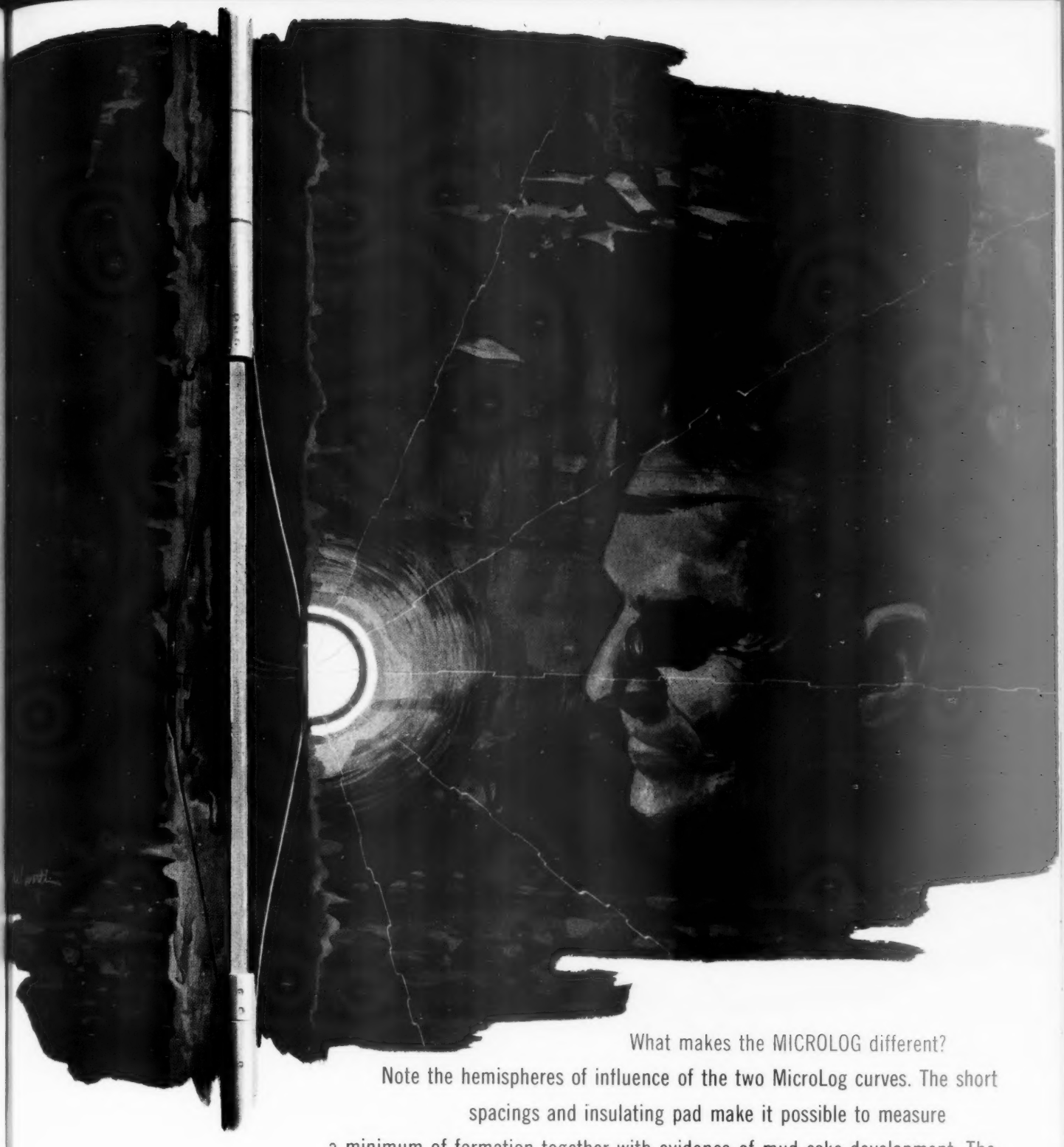
IS THERE A NEW APPROACH?

My final question is this:

4. Have we explored all of the possible or conceivable angles that might help us in developing the basin?

I have often wondered, and still do, whether there may not be some very simple relationship in the Appalachian basin which we have all overlooked that would give us better clues to what we are looking for. I am thinking both of new methods of attack and of new applications of older methods. It has been a very long time, I think, since we have come up with any basic new discovery or new formulation of geologic principle such as the carbon-ratio theory which we now pretty well discard. I wonder if it isn't about time to develop some new ideas, examine some new perspectives, and try a fresh approach to our problems.

Has anyone ever developed a migration map for the whole basin at some important horizon, showing the relative heights of all folds and the critical elevation of the spill-points from one fold to another, so as to reconstruct the probable pattern of oil and gas migration? In the area of storage, have all possibilities been explored in igneous



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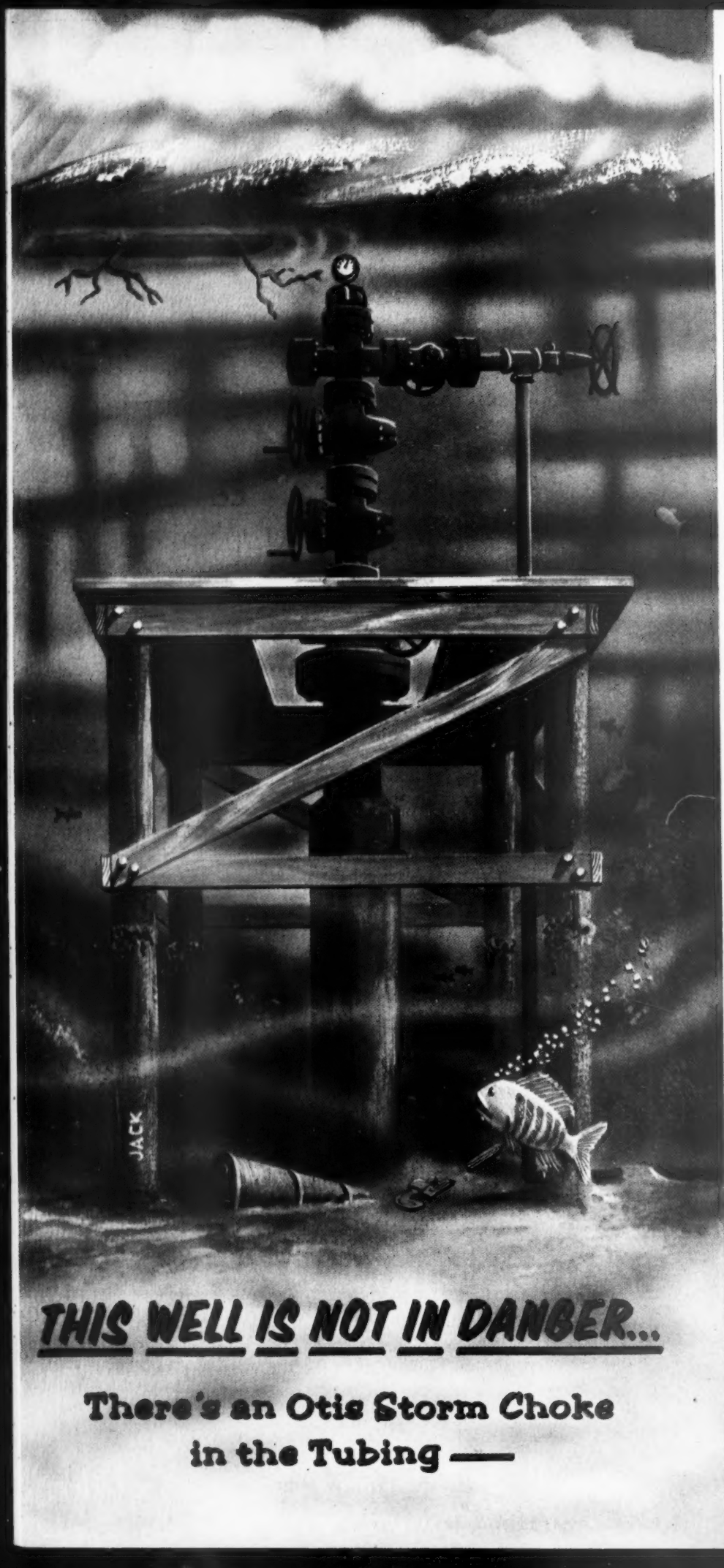
or metamorphic rocks, either near the surface or at depth? How about submarine storage possibilities?

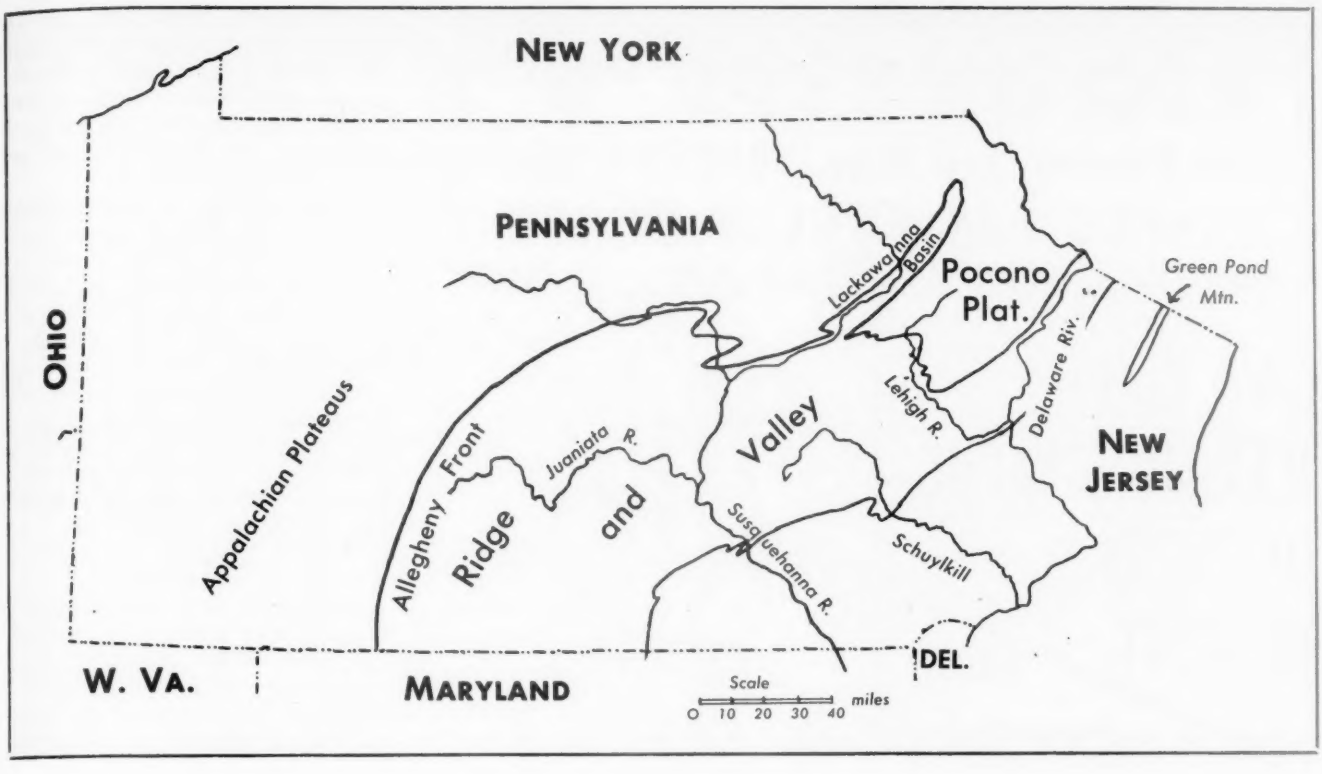
I notice they are now feeding weather data into an electronic calculator which thereupon grinds out a fairly accurate weather forecast. Is it possible that some of our data could be so mathematically arranged that more of the guesswork could be mechanically eliminated? In this connection, Professor Von Neumann at Princeton has made a pure mathematical study of what he calls the theory of games. For example he worked out in pure mathematics the problem of searching for a lost golf ball, and in a top-secret and highly successful war-time project, the Navy turned these same formulas into the solution of how to ferret out an enemy submarine. We, too, are searching for something in pretty much a haphazard way. I wonder, bizarre as the idea sounds if a better method of approach could be worked out in pure mathematics. How about oil or gas possibilities in the anthracite region of Pennsylvania? Could we extend Silurian production underneath Lake Erie?

In a very crude way I once planned detailed isopach maps on transparent film, building them up one above another to follow changes in the basin pattern. Isn't this a method that should be thoroughly tested to see what else can be learned? I'm sure each one of you has also thought of some curious or untried possibility; wouldn't it be wise to assemble these ideas and at least discuss their potentials?

In basic geologic matters, I feel that other producing areas are far ahead of the Appalachian country in realizing the importance of applying intensive and skilled research to specific or critical problems. I suggest to you that an excellent topic for your next discussion would be a critical analysis of the problems that ought to be worked out, perhaps starting from some of the suggestions made here. Finally, I am certain that such basic studies should not be left entirely to the pure scientist who cannot always obtain some of the very information that you already possess.

I still feel that the Appalachian basin represents an ideal area where a major program of cooperative geologic study could be of great significance. If what we all know already could be put together it would be an impressive and formidable total, and I think we could all operate a little more efficiently with this assembled information at our disposal. I wish you would give this some serious thought, and I hope you will come to regard it as one problem concerning the Appalachian basin that is capable of happy solution. * * *





Oil Potential in Northern Appalachians

Bradford Willard*

THIS article is a synopsis of the geology of the Northern Appalachian Mountains in central and eastern Pennsylvania and northern New Jersey. Mention also is made of the plateaus, Appalachian of western, and the Pocono in northeastern Pennsylvania. The writer is not an oil geologist. His aim is to describe the geology as succinctly as is commensurate with reasonable completeness, but without particular interpretation or deduction from the standpoint of the searcher for petroleum and natural gas. No recommendation, real or implied, for exploitation of oil and gas possibilities of the region is intended.

The portion of the Appalachian Mountains, which is the basis of this account, is that succession of parallel or concentrically aligned ridges which sweep up from Maryland into south-central Pennsylvania, bend in a great narrowing arc northeastward to the east-central border of the State, continue across northwestern New Jersey (Fig. 1). The mountains are carved from Paleozoic sedimentary rocks. To the south and east spread ancient crystallines of no present interest. West and north is plateau country where mountain folds subside into gently undulating structures, and a flatter land surface drops gradually westward toward the continental interior.

*Head, Department of Geology, Lehigh University, Bethlehem, Pennsylvania.

Physiography

Physiographically, (*cf*. Fig. 1) all the region embraced in this paper lies within the Appalachian Highlands Division and is assigned to two provinces, the Valley and Ridge to the southeast and the Appalachian Plateaus beyond to the west and north (Fenneman, 1946). The Valley and Ridge Province of second cycle mountains has undergone folding, uplift, peneplanation, re-elevation and dissection.

Here the geologic traveler is fascinated by the long, even crested ridges supported by resistant conglomerates, sandstones, and orthoquartzites and the interspersed valleys eroded from shales and limestones. Here, indeed, trellis drainage is exemplified at its best, as master streams, the Delaware, Lehigh, Schuylkill, Susquehanna and Juniata, transect ridge after ridge in majestic water gap series. Here, too, wind gaps hint of stream piracy and adjustment.

In complement, the plateaus fronting abruptly upon the valley and Ridge Province, slope gently away to the west and north. The Pocono Plateau in northeastern Pennsylvania is merely an outlier of the main feature, nearly divorced therefrom by the structurally anomalous Lackawanna Basin.

Stratigraphy

The base of the stratigraphic pile rests upon a pre-Cambrian metamorphic-igneous complex. Thereon rises an aggregate thickness of several miles of Paleozoic sedimentary rocks. In New Jersey these range in ages from

What about petroleum potential in Eastern Pennsylvania and New Jersey? Do the stratigraphy and structures give any encouragement to oil exploration? Why has this area been so neglected in the past? This exclusive article supplies some clues to the future of the province.

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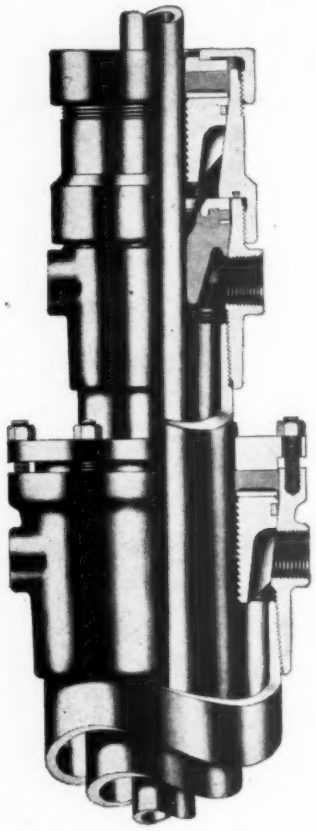

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Appalachian

early Cambrian into Devonian. The Pennsylvania succession transcends that of New Jersey in that it continues to the close of the Paleozoic, albeit the Permian, found only in the southwest corner of the state, is not germain to the present discussion.

Reams might be printed descriptive of the stratigraphy, the many formations, their facies changes, distribution and so on, *ad nauseaum*. Such an account is here impossible, even if it were appropriate. The succession is tabulated below. To those who seek amplification, reference should be made, first to the geologic maps of Pennsylvania (1931) and New Jersey (1940) and second to the voluminous literature. The appended bibliography lists only a few lead articles.

Structures

Speaking broadly, the structures in Pennsylvania's mountains are simple, open folds. Many are slightly asymmetrical, steeper limbs to the north or northwest. Dissection and denudation have cut so deeply that the general rule is anticlinal valleys and synclinal mountains. More precisely, the ridges are monoclinal, arranged in pairs facing one another across anticlinal valleys. Anticlinal ridges are uncommon but are exemplified in the incompletely dissected noses of plunging arches. Such plunging folds account for the zig-zag rock formation pattern of central Pennsylvania.

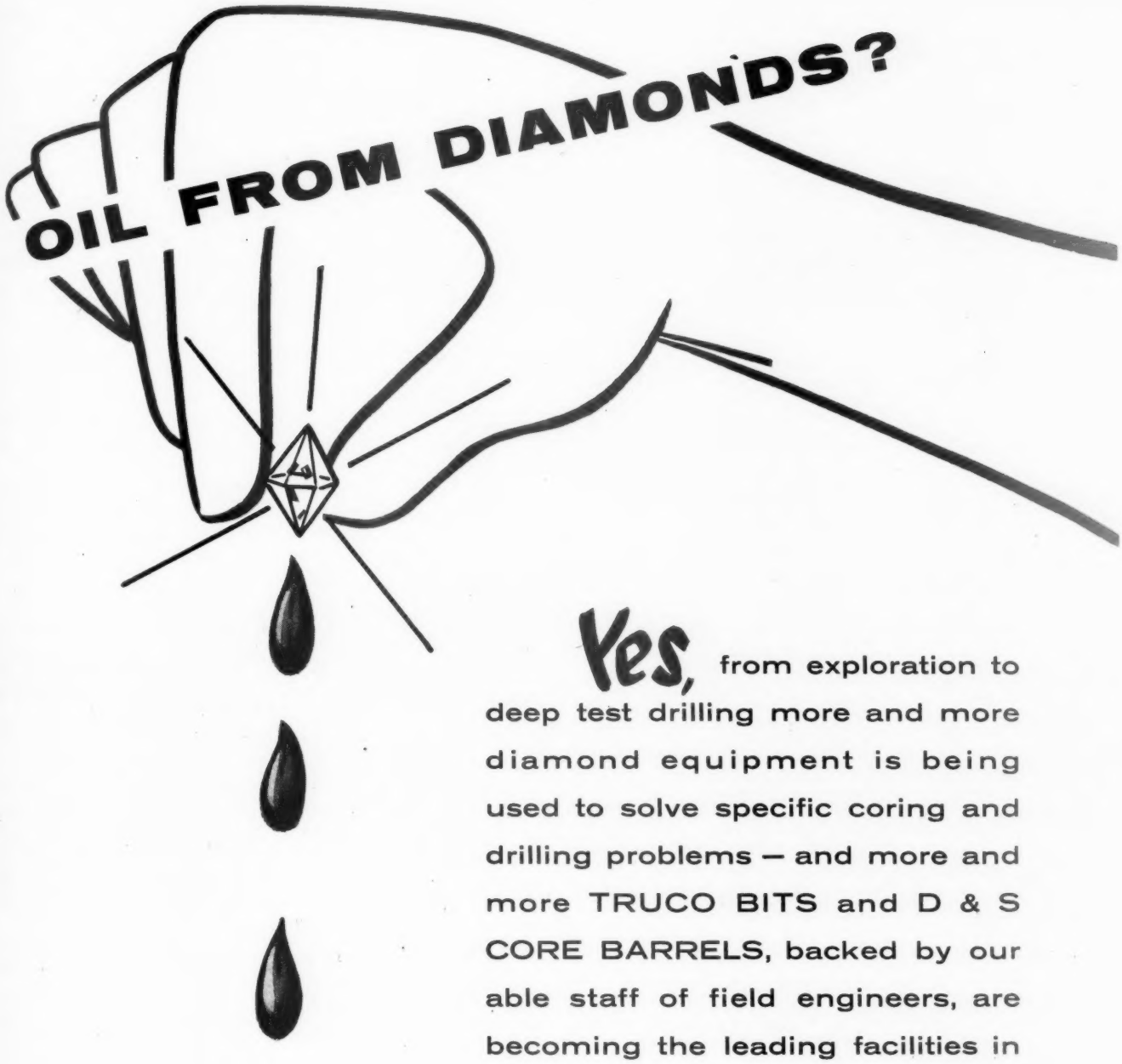
Faults with throws in excess of 100 ft are not common. A few thrusts have been recognized, and normal faults are plentiful but small, associated with folds, flank or axis. Exceptional are occasional, comparatively large, normal faults which bear no apparent relation to the general structural pattern and are believed to have been superimposed thereon. This is understood when we observe that the dominant folds are of late Paleozoic age, but the larger normal faults are assigned to late Triassic or even Jurassic time.

Crossing into New Jersey, a noticeable structural feature is the long, narrow Green Pond Mountain syncline which extends some 45 miles southwestward from the north-central point on the New Jersey-New York boundary.

This sharply down-warped area is cut by a number of strike faults. The main body of the Paleozoic rocks in New Jersey, which lies southeast of the Delaware, is structurally a succession of long, narrow folds. As in the Green Pond Mountain syncline, they are interrupted by several faults. Normal faults are more common. All are recorded with high dip angles.

To all the foregoing structural comments, there is one region which is

OIL FROM DIAMONDS?



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Summation of stratigraphic succession of Paleozoic systems of Pennsylvania and New Jersey.

Distribution, lithology and thickness*

System	Pennsylvania	New Jersey
PENNSYLVANIAN	Bituminous coal measures underlie much of the Appalachian Plateau. Anthracite fields are in the east as a group of basins between the Susquehanna and Lehigh Rivers, plus and Lackawanna Basin, a long, narrow extension into the northeast corner of the State. Besides coal, the system includes fresh-water-formed sandstone, shale, siltstone and occasional limestone lenses plus a few thin, but widespread, marine limestones. A basal conglomerate or sandstone is a ridge-maker, particularly in the anthracite fields. Western: 1750 ft. Eastern: 1300 ft.	Absent
MISSISSIPPIAN	Distributed as bands surrounding the anthracite basins and thence westward, it comes to surface along a few low, dissected anticlines of the Appalachian Plateau, and is much exposed in the northern part thereof. *n. b.* The distribution of Mississippian rocks on the Pocono Plateau shown in the State map is largely erroneous. Most of the Plateau is capped by Devonian beds. The system is divided into two main parts, the upper, red beds, the lower, gray sandstone and conglomerate and thin, non-commercial coals. In the southwest, thin marine limestones are intercalated. The lower part of the system is a prominent ridge-maker in the anthracite fields and the Susquehanna and Juniata Valleys. Central: 2400 ft. Eastern: 4300 ft.	Absent
DEVONIAN	Widely distributed along the northern edge of Appalachian Plateau, across the Pocono Plateau, throughout central and eastern portions of Appalachian Mountains. The system resolves into two major phases, marine *vs.* continental. Marine beds are sandstone, shale and an occasional limestone. The continental is a mass of red and green or gray-green sandstones and shales, thickest in the east, thinning upward and westward. The whole system illustrates the sedimentary cycle exceptionally well: marine on-lap, maximum sea expansion, off-lap, followed by incursion of continental strata. Certain sandstones, mostly near the middle of the system, are prominent ridge-makers in the Susquehanna and Juniata Valleys; otherwise the Devonian tends to underlie low, undulating topography. Central: 7500 ft. Eastern: 6700 ft.	Two areas: northwestern adjacent to the Delaware River, and the Green Pond Mountain syncline, north-centrally situated. The latter is complementary to the Pennsylvania sequence as more completely continental with a sequence of marine beds at base. The Delaware Valley succession is much the same as in adjacent Pennsylvania. Green Pond Mtn. syncline: 4500 ft.
SILURIAN	Silurian formations support Pennsylvania's most prominent mountains and underlie adjacent valleys. Like the Devonian (*q.v.*), there are complementary marine and non-marine phases. In eastern Pennsylvania, a thick marine sandstone and conglomerate is succeeded by an even thicker series of red beds, then a sliver of marine limestones and shales. Westward, in the central counties, the Silurian is almost entirely marine, with only a thin remnant of red beds retained. The Lower Silurian sandstones and conglomerates are the principal ridge-makers in the State. Central: 2500 ft. Eastern: 2400 ft.	Adjacent to the Delaware Valley, all is much the same as in Pennsylvania, and continuous therewith. In the Green Pond Mountain syncline in the north-central part of the State, nearly the entire system is continental and complementary to the more western succession. Green Pond Mountain syncline: 1500 ft.
ORDOVICIAN	The fertile limestone valleys of the central counties and those valleys south of the more mountainous tracts in the east are cut in carbonate rocks, partly Ordovician, partly Cambrian. Adjacent to the limestones are bands of Upper Ordovician shales (or slates). From the Susquehanna and Juniata Valleys southward, the Ordovician continues into Maryland. The Lower and Middle Ordovician carbonates are sometimes high in $MgCO_3$, sometimes in $CaCO_3$. Bentonites are reported. In central Pennsylvania the carbonates are overlain by shale which becomes slate in the east. From south-central to central parts, sandstones and conglomerates of continental genesis overlie the shales. All the older strata are marine save for a few red beds in the east. Between the Schuylkill and Susquehanna valleys, basic igneous rocks cut the Ordovician sediments. Except for the highest beds which are ridge-formers in central Pennsylvania, the Ordovician rocks tend to underlie relatively low land. Central: 7500 ft. Eastern: 5800 ft.	The system in New Jersey is identical with that of eastern Pennsylvania. Limestone-floored valleys and belts of slate cross the State from east-central Pennsylvania northeastward to the New York State line. Because in New Jersey the Lower Ordovician has not been separated from the Cambrain carbonate rocks, the total thickness cannot be quoted. It is presumably the same as in Pennsylvania.
CAMBRIAN	The Cambrian in Pennsylvania, like the Lower Ordovician, is found in the great limestone valleys of east-central, central and south-central districts. A basal Cambrain sandstone, quartzite and associated rocks fringe the pre-Cambrain gneissic hills. The carbonate rocks which predominate are usually high in $MgCO_3$. Central: 2700 ft plus, base hidden Eastern: 2400 ft.	*Cf.* discussion under Ordovician. the two systems have not been differentiated in New Jersey. Thickness is presumed to be the same as in eastern Pennsylvania.

* Most of the thickness figures represent the maximum which may be expected.

quite exceptional. In eastern Pennsylvania and across New Jersey at some distance southeast from the Delaware Valley, a district called the Great Valley, the Lower Paleozoic rocks of the southern half of the folded mountains have been much more disturbed than elsewhere. The orogenic history accounts for this difference. Most of our Paleozoic structures, originating during the Appalachian Revolution at or near the close of the Paleozoic era, affected all of the Paleozoic formations. In New Jersey and in eastern Pennsylvania, however, about as far west of the Schuylkill, 40 miles west from the Pennsylvania-New Jersey line, the older rocks were affected also by the Taconic Disturbance which reached its peak in late Ordovician times. Note, this was *late* Ordovician, but not quite the close of that period. Historically, then, the Cambrian and the Ordovician sedimentary rocks in the east underwent two intervals of compression, whereas only one orogeny affected the younger beds in the east and the whole sequence beyond. Because of these two intervals, the eastern Cambrian and Ordovician carbonate rocks are complexly folded and faulted, and the overlying Upper Ordovician shales have been changed to slate.

Another result of the Taconic orogeny was the inception of the only major *angular* unconformity in the eastern Paleozoic sequence. Following the Disturbance, uplift and erosion peneplaned the surface. Across this surface, in eastern Pennsylvania and northern New Jersey, Silurian beds transgressed in angular discordance. In central Pennsylvania where the Taconic Disturbance was non-affective, additional Ordovician sediments, all continental in origin, formed prior to the Silurian marine incursion.

There are, of course, disconformities in the Paleozoic. Portions of the Lower Devonian or even Middle Devonian may here or there be missing. Likewise, a local "break" may separate the Mississippian from the overlying Pennsylvanian continental beds. There are interruptions in the Upper Cambrian sequence and between the Cambrian and Ordovician in the Delaware Valley. But in each instance, there is known *no angular* discordance, and all diastems appear to be of little or no significance.

Oil and Gas?

Until quite recent years, search for oil and gas in Pennsylvania was almost confined to the western Plateau. Today, more attention is being paid to the folded Appalachians in the state, but as yet New Jersey is almost totally neglected. It is difficult to account for the indifference because the stratigraphy and structures have so long been known, and published accounts have been readily available.

For example, the excellent geologic map of Pennsylvania by Henry D. Rogers came off the press in 1858, a year before Drake drilled his Titusville well. Perhaps the fixed carbon dogma and the lack of spectacular gas or oil showings in the east are responsible for the apathy. Some years ago, R. E. Stevenson and the writer (1950) summarized the conditions for eastern New York and northeastern Pennsylvania. As our words are still applicable, this paper is terminated by these quotations from that reference:

. . . Levorsen (1948, p. 287) writes:

> Reduced to their simplest terms, the geologic factors which favor a region as a potential petroleum province are: (1) sediments; preferably but not necessarily marine, variable, and unmetamorphosed—generally the more the better; (2) evidences of oil and gas, either from surface seepages or showings in wells; (3) unconformities—also the more the better; and (4) up-dip wedge belts of permeability resulting from any cause.

He continues (*op. cit.*, p. 295):

> One of the important functions of unconformities is to mark the trunca-

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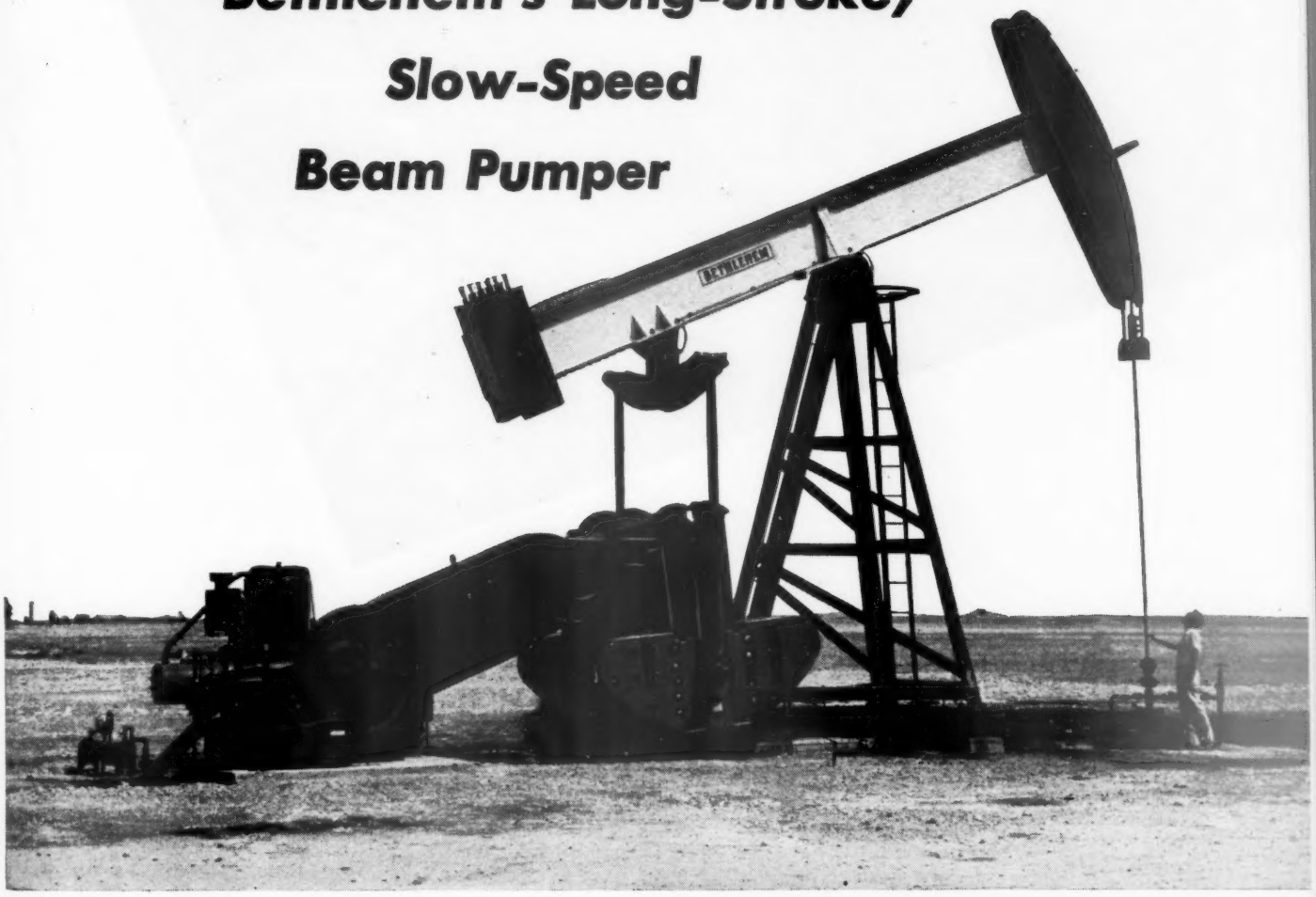

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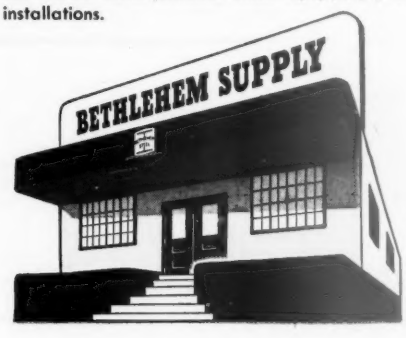

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tion of porous formations below the unconformity. Likewise, the overlapping formations above the plane of the unconformity often contain porous members or lenses.

Levorson mentions also such items as "numerous changes in facies, lateral variations in porosity, limestone reefs and interbedded continental and marine sediments" . . . "Gentle folds, structural terraces and other minor structures . . ."

Of the conditions named by Levorsen, the parts of Pennsylvania and New Jersey here mentioned are most deficient in shows of gas and oil, although recently, confidential reports to the author are encouraging.

There is a vast thickness of variable marine strata representing the several systems. In the Ordovician, Silurian, and Devonian are appreciable thicknesses of complementary continental beds. The Mississippian and Pennsylvania systems are nearly entirely of fresh water origin. The shifts between unlike phases and widespread shifts among the marine beds themselves are obvious. Only one major angular unconformity is known. Disconformities are local. Moderate folding is the rule. Thrust faulting is rare. There are many normal faults whose affect upon escape of fluid hydrocarbons is obvious. Limestones are dominant in the Cambrian and Lower Ordovician, become scarcer above. Some older ones are notoriously cavernous. At least one reef has been recognized in the Devonian in eastern Pennsylvania.

All of this adds up to a situation which may lead some to "take a chance." Minute field work plus geophysical studies are certainly in order. As the search for petroleum quickens, even such marginal areas as here described will doubtless receive attention.

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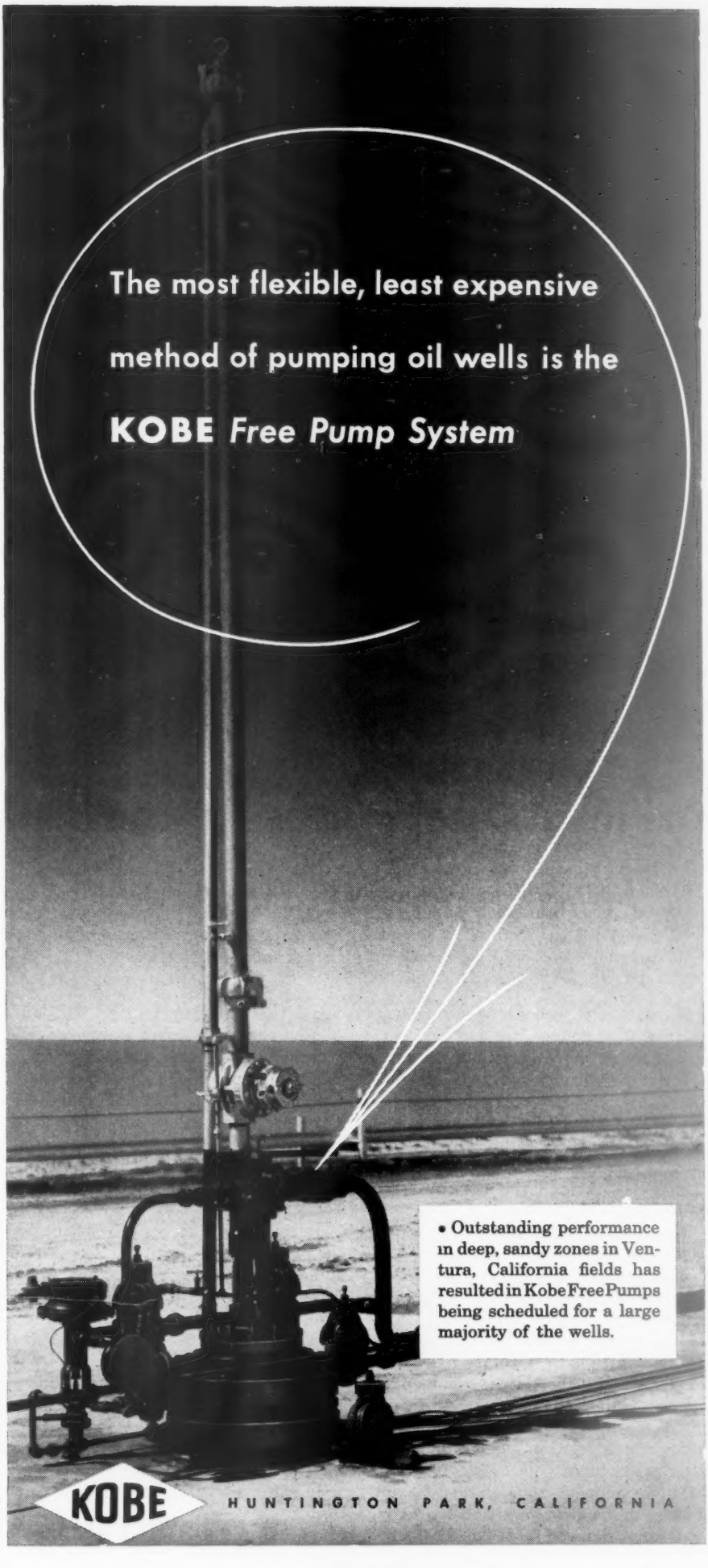
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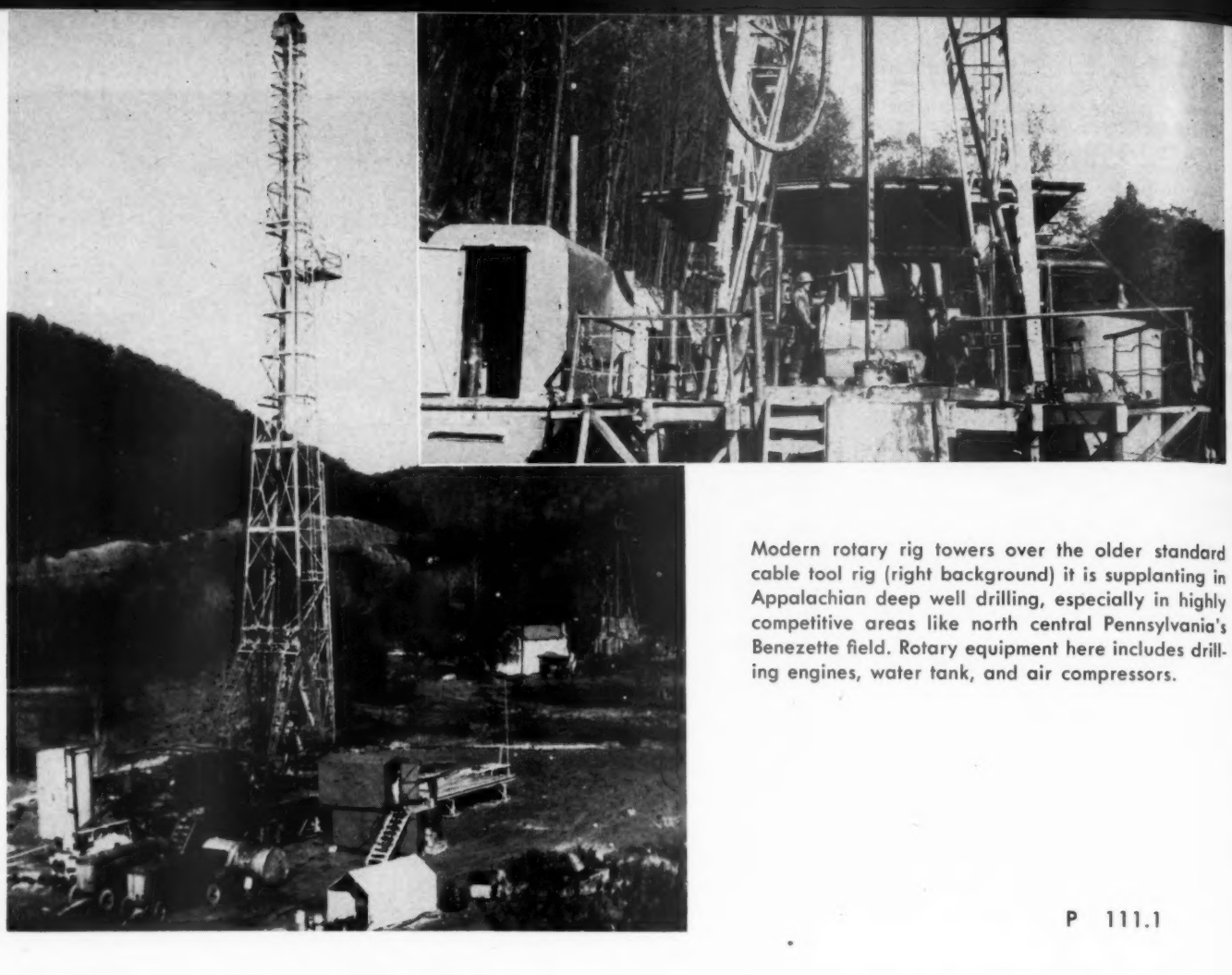

Modern rotary rig towers over the older standard cable tool rig (right background) it is supplanting in Appalachian deep well drilling, especially in highly competitive areas like north central Pennsylvania's Benezette field. Rotary equipment here includes drilling engines, water tank, and air compressors.

P 111.1

Drilling Operations in the Appalachian Basin

Rotary drilling has taken hold only recently — air circulation coming into use

S. G. Day

THE past three years have brought a great deal of change in deep well gas operations in the Appalachian Basin.

Prior to and including most of the 1950-52 Leidy gas field development in Clinton County, Pennsylvania, practically all deep well drilling was with cable tools. These ranged from the older standard rigs to the more modern spudders.

The few exceptions were rotary tests, which did not prove too successful because they were made ten or more years ago when the equipment, especially the bits, was far from its present stage of development.

Later attempts with rotary rigs were necessitated by the deeper productive zones encountered in the Leidy field. Out of those and subsequent uses of the rotary has emerged its establishment in the Appalachians.

The producing zone in the Leidy field, as in the Driftwood and Benzette fields that followed it, is the Oriskany Sand, Lower Devonian Age. The formation ranges in depth in these fields from 6300 to 7300 ft. The first marker formation encountered is the Tully lime, approximately 800 ft above the Oriskany. Below the Tully cable tool rigs often encounter gas bearing sand or shale stringers, which "blow up" causing stuck tools, fishing jobs, and occasional fires.

In this Marcellus Shale zone, below the Tully and above the Onondaga Lime, which covers the Oriskany, cable tools often have severe sloughing problems requiring numerous cementing jobs to remedy. There does not seem to be any standard cure to solve this problem as cement is either dumped down the hole or deposited on the walls with a spray bailer and allowed to set either a long or a short period of time; each method has varying success.

In setting a string of 7-in. casing in

EXCLUSIVE

The Author

S. G. "Steve" Day practically grew up in the gas business, having been reared in Washington, Pa., when that community was the center of gas production activities in Southwestern Pennsylvania.

He joined Manufacturers Light and Heat Company in 1930 as a clerk in the Waynesburg, Pennsylvania, field office. After several promotions he was appointed a well inspector in 1937. He was advanced to assistant superintendent of the firm's southwestern Pennsylvania production and transmission division in 1940. He was appointed superintendent of production for the Pittsburgh Group Companies, Columbia Gas System, in 1952. He is a member of Pennsylvania Natural Gas Men's Association and the Research Institute of America.

Mountain location of this rotary is typical of rugged drilling terrain encountered in Benezette gas field. This rotary has a 126-ft mast. Stacked in lower foreground is 3½-in. drill pipe.

Standard cable tool rig, still in extensive use in the Appalachians has changed little in appearance over the years. This rig overlooks Manufacturers Light and Heat field office near Grant, Pennsylvania.

Spudders like the Bucyrus-Erie type shown here have often been teamed up with the rotary in the Benezette field. Faster than the standard rig, spudders are capable of drilling to and beyond the 6000-ft levels.

the Onondaga, most conventional rigs have been incapable of handling the casing as it should be done. Often it has been necessary to use hydraulic jacks to handle the last several hundred feet of casing run in the hole. The casing program with the cable tool runs approximately as follows:

50 ft . . . . . 13⅜-in. casing
200 ft . . . . . 10¾-in. casing
800 ft . . . . . 8¼-in. casing
7-in. casing into the Onondaga

The only casing cemented in the hole is the 7-in., also known as the production string.

Since the casing is set in the Onondaga immediately above the Oriskany pay zone, 15 to 30 ft of lime and chert must be drilled before encountering the gas. The Oriskany is then either drilled or shot in, or a combination of the two methods employed. The safest method is to drill the first few feet of the sand or until the first gas show and then use a production shot for the remainder.

Methods used to increase production are the directional shot and sand fracturing. Of the two methods the directional shot has proved more successful in the Oriskany. Sand fracturing has been attempted in very low production wells where the increase has either been too low or too short-lived to warrant laying a line to the well to take the gas.

As there is no state conservation commission in Pennsylvania to regulate well spacing, there has been a large amount of "town lot" drilling in the Leidy, Driftwood, and Benezette fields. That has meant that large tract holders have no guarantee of gas volume in proportion to the size of their holdings. The only recourse is to complete a well before the adjoining leaseholders.

The obvious answer under those circumstances was to haul in and use the rotary rig. It was discovered that although the cost of rotary drilling was higher, the amount of gas obtained in the period of time saved over the period required to drill with cable tools would more than compensate for the increased cost of drilling. In some cases the cost of drilling with rotary was much less than the cost of cable tools because far less trouble was encountered in the drilling operations.

The method found to be best, whenever the schedule permits it, has been to spud in with cable tools and drill to the surface casing depth and set it. This depth ranges from 600 to 800 ft. To prevent later troubles the casing—in most cases 10¾-in.—is cemented from top to bottom. This is sometimes a problem when a bad thief zone is encountered. After setting the surface casing the rotary rig is moved in and used to drill to and set casing in the Onondaga lime. Geologists are at the well to identify the marker horizons as they are reached. The production casing is cemented to fill up to the Tully Lime approximately 800 ft above bottom. Normal procedure is to move cable tools back and complete well.

A major deviation of the above described method is to drill to the top of the Oriskany with rotary tools with lightweight mud (usually 8.5-8-7 lb per gal) and then shut down and condition the mud. The mud is weighted up to offset probable formation pressure and drilling is begun again and hole is made through most of the Oriskany.

First an electrical log and an open hole production test is run to determine the pressure and approximate amount of gas. This method can prove much cheaper if the well is non-productive, but more expensive if production is found. There is also a question in the minds of many geologists and engineers as to the harm, if any, that a barite-weighted mud might have on the producing sandface.

The latest change in drilling methods has been the use of air as the circulatory medium. It has even been found possible to drill all the way from the surface to the production casing zone using air. The surface casing is usually set with cable tools or with rotary using water and then switched over to air. The hole is then drilled to the Onondaga, casing set, and drilled in with gas. This method has proved to be considerably faster than any previously used. * * *

Business end of the rotary is its drilling bit displayed here by a Fryer & Hansen crew member at well in Medix Run, Benezette gas field, Elk County, Pennsylvania.

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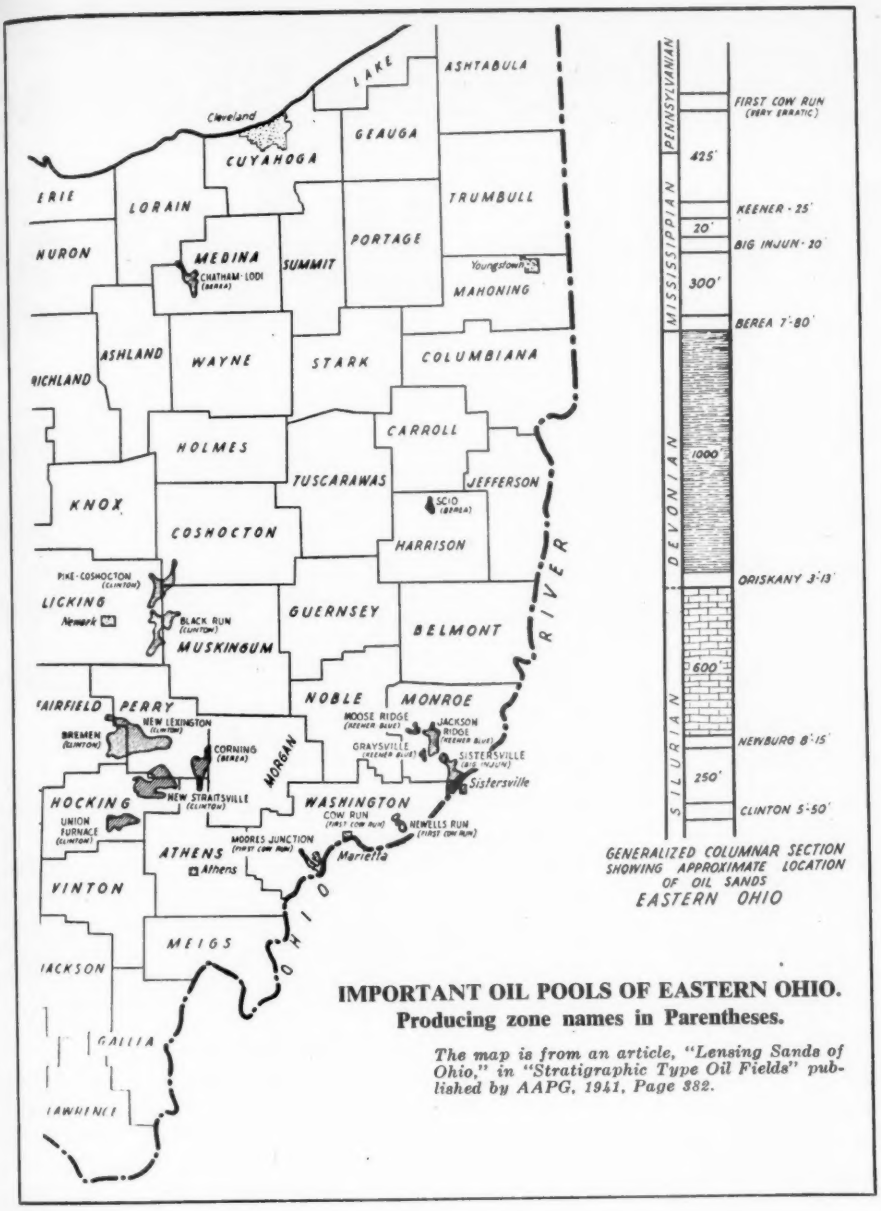

IMPORTANT OIL POOLS OF EASTERN OHIO.
Producing zone names in Parentheses.

The map is from an article, "Lensing Sands of Ohio," in "Stratigraphic Type Oil Fields" published by AAPG, 1941, Page 382.

secondary recovery and new drilling give OHIO wide potential

Edward V. O'Rourke

EXCLUSIVE

Geophysical work is widespread in this old oil-producing state—waterflooding has been successful and costs are not high—marketing difficulties have limited new drilling.

ALTOGETHER, the State of Ohio is not an important oil producer. The total amount of crude oil produced is 10,000 bbl per day and the state uses 400,000 bbl per day of petroleum products.

GEOLOGY

The Geological Survey of Ohio published a book entitled *The Occurence and Exploitation of Petroleum and Natural Gas in Ohio,* by John A. Bownocker, 1903. This includes the best portrayal of the geology of northwest Ohio. In that area the Trenton limestone was important as an oil producer, accounting for in excess of one-half of all the oil that has been produced in this state.

The American Association of Petroleum Geologists published a book in 1941 entitled *Stratigraphic Type Oil Fields.* Pages 382-385 refer to the "Lensing Sands of Ohio," by E. V. O'Rourke. This gives a condensed description of the geology and oil and gas producing horizons of eastern Ohio. There is a map in this article showing important oil pools in eastern Ohio.

EXPLORATION METHODS

Through northwestern Ohio there could have been geophysical prospecting and core drilling for structure. In fact, these methods are being used in the northwest portion of the state endeavoring to find new fields, particularly in Trenton Age.

In the Clinton producing area, old records of drilling where there were shows of oil are studied. New holes are drilled nearby. Fracturing is used and has been responsible for much of the new production in the last two years. Each well is a wildcat. Chances are better offsetting good production, but each well is still a gamble.

This writer knows of no geologic or geophysical method which can be applied to aid in finding oil and gas pools in the Clinton horizon. No relationship exists between structure and accumulation of oil and gas in this formation. There was a great deal of attention given by major companies to eastern Ohio during 1939 and 1940. Considerable geophysical work was carried on at that time in northeast Ohio. Detailed geophysical work should be of benefit in finding potential Oriskany and Newburg producing horizons.

DRILLING, PRODUCING PRACTICES

With a few exceptions, drilling in Ohio has been done with cable tools. The cost of cable drilling has been relatively low and there is need for few

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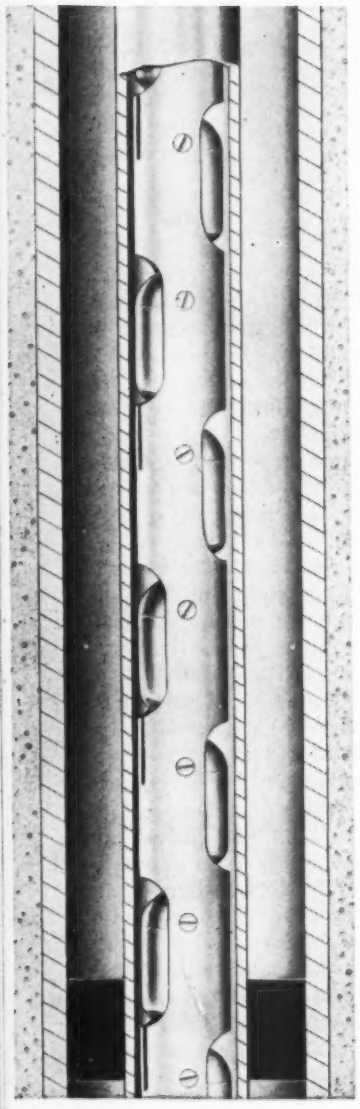

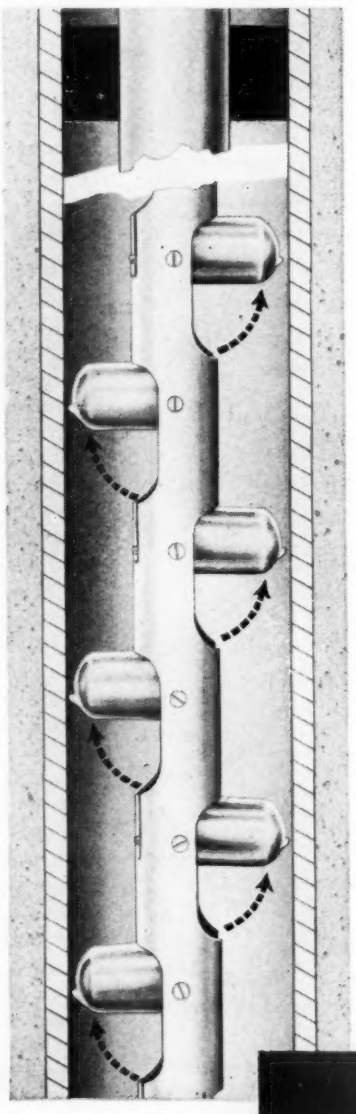

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At right, full-powered jets are snapped into position at firing zone.

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Gulf Coast

In Zapata County, a gas well had been perforated and was making only one-half million cubic feet. One run with the Welex Swing Jet to perforate 12′ at four holes per foot resulted in an immediate increase to one million cubic feet. A test four months later showed the well was producing 4 million cubic feet.

West Texas

A well in Andrews County had been set up for a permanent type completion in order to economize completion costs. The mud in 5½″ casing was displaced with oil, and open-end tubing with a hook-wall packer was run to a point just above the perforating zone. A single run was made with the Welex Swing-Jet to perforate the interval 12,606′ to 12,619′, four holes per foot. Before Welex equipment could be moved from the location, the well was cleaning and flowing to pits without chemical or hydraulic treatment.

Oklahoma

In Grady County, Welex Swing Jet was used to perforate 20′ from 10,225′ to 10,245′ at 8 holes per foot. Following three swabbing runs, the well flowed 94 barrels of oil per hour. A test two months later showed same rate of flow and zone had not been treated in any manner.

Additional data and identification of the wells above can be obtained by writing Welex Jet Services, Inc., Fort Worth.

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casing strings in connection with water shut-offs. When production has been sufficient to warrant sitmulation, nitroglycerine or gelatin dynamite has been used in shooting. This practice gave way to fracturing in the latter part of 1952. A paper by Jack Lee Mahaffey, published in *Producers Monthly*, September 1954, page 26, gives detailed account of fracturing results in eastern Ohio. The article presents the essential procedure followed in the fracturing treatment.

Practically all oil production has been pumped by sucker rods actuating plunger pumps at the bottoms of holes. Considerable revenue from natural gas sales has been derived through the last 45 years. The depth to production in the Clinton area averages about 3000 ft. The present cost is about $18,000 for a completely equipped well and approximately one-half of this can be salvaged at the end of production.

POTENTIAL PETROLIFIC AREAS

There should be some Trenton production found from time to time. The last notable "strike" was north of Tiffin, in Seneca County. It is my understanding that there is considerable prospecting along the Indiana border at the present time. That area and the western part of Ohio has a chance to supply more oil and gas.

The Author

As an authority on oil production and research, Edward V. O'Rourke, professor of petroleum engineering at Ohio State University, has had broad professional experience with mining and petroleum firms both in this country and abroad.

A graduate of Ohio State, he has been employed by such firms as the Braden Copper Company, Nevada Consolidated Copper Company, Marland Oil Company, Phillips Petroleum Company, the Maracaibo Oil Exploration Company; and Gulf Oil. He has also served as consultant to the Shell Oil Company; the Fercleve Corporation of New York, which built the gaseous diffusion plant at Oak Ridge, Tennessee; and to Stark and Summit Counties, Ohio, for gas field evaluations.

O'Rourke in 1949 was appointed a member of the Engineering Committee of the Interstate Oil Compact Commission. He holds membership in the American Institute of Mining Engineers, the American Petroleum Institute, and the American Association of Petroleum Geologists, and was national secretary of Sigma Gamma Epsilon, earth science society, in 1950-51.

It is likely that Berea production will be found from time to time in the eastern half of the state. In the last few years, considerable gas production has come from this formation in Meigs County and, considerable oil production in the same formation and in the same county.

Gas from Devonian shales is always possible. Lately there has been new interest in this formation in Noble County.

The Oriskany formation is sought after from time to time. Gas has been found in this geologic horizon in Washington County during the last few years. In the northern part of the state, the Newburg and Oriskany have given some fair oil and gas production, particularly through Summit and Cuyahoga Counties. There is a huge area in eastern Ohio where Clinton oil and gas production is possible. Most new Corning grade production comes from that horizon. The "hits" are not too frequent, but when found, the area sometimes spreads to fairly large acreage. I believe that drilling will go on for many years in the potential Clinton area, as long as the price of oil is conducive to the search. If and when Pennsylvania grade prices increase, drilling and exploration in areas that produce that grade will be resumed.

Production will not rise to a very large figure as declines are rapid for the first year. New drilling has usually been responsible for keeping the total production on an even keel. There has been some exception to this, particularly during 1953. Increased oil production, as a result of fracturing, brought on a great wave of drilling and subsequent oil production. This continued until about mid-1954, when the buyers of Corning grade began to pro-rate the taking of this grade of oil.

SECONDARY RECOVERY

The Chatham pool, in Medina County, is the only locality so far where water flooding for oil production is extensively practiced. This is described in API Bulletin, "Secondary Recovery of Oil in the U. S.," 1950, pages 477-485. The Scio pool, in Harrison County, would appear to be worthwhile testing since the first recovery there was substantial. Portions of northwestern Ohio where original Trenton production was high are also worth investigating. There were some sizable recoveries from the Big Injun, near Sistersville, West Virginia, which borders the Ohio River. Average production in Clinton has not been very great. There are a few concentrations, some of which at the present time are being gas pressure produced, and these also seem to be prospective water flood areas. There is little or no corrosion of pipes in connection with Clinton production.

The greatest possibility to increase production would be for successful, rather widespread application of water flooding methods to old Trenton production. As pointed out before, this formation accounts for approximately one-half of the total amount of oil that has been produced in Ohio, and while the general average of production per acre was fairly low, there must have been a number of areas which produced amounts from 3000 to 4000 bbl or more per acre. The depth to this formation is usually not much more than 1200 ft, so that drilling costs for secondary projects should not be high. Nearly all the wells which formerly produced Trenton oil have been abandoned. It is my understanding that most of them were properly plugged.

A major oil company carried on some coring operations in the Trenton about a year and a half ago. The results of analyses of cores taken in these tests have not been published.

PRICE STRUCTURE

The present price structure in Ohio, as published by the Ohio Oil and Gas Association, is as follows:

Buckeye-Penna	$2.76
Zanesville-Penna	2.62
[1]Corning	2.72
[2]Corning	2.65
Cleveland-Chatham	2.62
Lima	2.50

[1]Ashland Oil & Ref. Co.
[2]Joseph Seep Purchasing Agency

The price of Buckeye-Penna and Zanesville-Penna are about $2 less per barrel now than the posted price in the autumn of 1948. Therefore, little exploration is carried on in the areas that yield oil of Pennsylvania grades. The Cleveland-Chatham refers to the grade of oil produced in the water flooding operations of Chatham Township, Medina County field. The Lima grade applies to northwest Ohio and the production there is relatively low.

GENERAL DRILLING ACTIVITIES

For some time it has been realized that productions per acre from Clinton are on an average larger in the Corning grade area than Pennsylvania, and this combined with the success due to the fracturing methods has brought about a fair amount of drilling in which it is hoped that Corning grade production would be found. In this past year, there has been some marketing difficulties of Corning due to the general potential over-production of oil and these circumstances have caused a drop-off of drilling operations.

* * *

End of Series

Lateral Drain Hole Drilling

California operations reviewed and conclusion from the study of more than 70 wells in which laterals have been drilled are presented.

SIXTEEN wells operated by one company located on four leases in the Edison, California, field were completed with lateral drain holes from June, 1950, to March, 1953. All wells were bottomed at an average depth of about 4300 ft in a pay section of about 125 ft of lenticular beds of oil sand.

The daily production of these wells varies between 4 and 70 bbl of oil per day at present. Unfortunately it is virtually impossible to state definitely whether the drilling of lateral drain holes in the original completions has benefitted the production of these wells. The production superintendent considers that one of the reasons that these wells are not more productive is the production of sand. Undoubtedly this plugged the laterals soon after they were drilled. The technique of completions with drain holes has advanced to the point where if these holes were drilled today they would be individually lined with prepacked liners.

Two recompleted wells on these leases indicate that the drain holes have benefitted their production.

Well "A" was put on production in June, 1944. Originally completed with slotted liner the well was later gravel-packed and produced. In June, 1951, a window was milled in the 7-in. casing and the well was redrilled from 4144 to 4297 ft. Four lateral drain holes were drilled with lengths varying between 18 and 44 ft, averaging 27 ft. The main bore was packed with ¼ by ⅜-in. gravel and the well was put on production. Just previous to the workover it produced an average of 3 bbl per day. Initial production immediately following the remedial work was 45 bbl per day which declined rapidly to a settled production of about 7½ bbl of oil per day. This average has been maintained for about one and one-half years and has shown no tendency to decline. A comparison of cumulative production for an 18 months' period before and after the recompletion of the well with drain holes reveals that oil produced before the workover totalled 2400 bbl, while in a like period after drainhole drilling 5000 bbl were produced. Of more significance is the fact that the well is maintaining its production rate and does not seem to be declining as it was before. This is illustrated in Chart No. 1.

Well "B" produced until August, 1952, when it had declined to one bbl per day. The well was then sidetracked and 44 ft of new hole was drilled with laterals. Before gravel-packing the producing zone, the drain holes were circulated clean with oil emulsion mud. The vertical bore was packed with 59 cu ft of ¼ by ⅝-in. gravel. Initial production of the well was 12 bbl per day gross with a cut of 44 per cent or net production of 7 bbl per day. Very little tendency to decline has been noted in this well as is shown in Chart No. 2. The well has averaged 7 bbl per day since the workover. Cumulative production for 14 months previous to and following the drilling of drain holes has totalled 552 and 3209 barrels of oil. The yield of this well was increased about 500 per cent.

Reworks in Depleted Zones

The reservoir in the Torrance field is composed of tight, well cemented sands interbedded with shale. In spite of the lenticular nature of the sand the zone is very productive since the shale is saturated with oil. The lease considered in this report first was drilled in 1924 and many of the wells have not been pumped for a number of years. Cumulative production of the wells averages from 100,000 to 120,000 bbl of oil. Very little or no gas pressure exists in the oil zone at present. Those wells still pumping on this lease average about five bbl of oil per day.

Well "A," which had not produced since 1929, was redrilled from 3100 ft to 3800 ft depth in September, 1952. Eight drain holes averaging about 75 feet in length each were drilled in the oil sand. Entry was made into all drain holes after drilling was completed and they were circulated clean but no liners were set. The main bore opposite the oil sand was gravel-packed and no liner was set. The first two days production averaged 39 bbl per day. Then the yield settled to around 20 barrels per day for the next month. Inspection of the production chart on this well (Chart No. 3) shows that the average yield since September, 1952, has been about 19 barrels per day or an average increase of 14 bbl per day over the other wells on this lease. This well is not considered too good an example for a redrill since the reservoir in its vicinity is depleted.

Since it has been recompleted with drain holes it has produced about 5300 barrels of oil more than the average well on the lease. Production does not seem to be declining from that established over a year ago. Probably there would be a better and more long-lived yield if the drain holes had been lined with prepacked liners and adapters. This well is a good example of the beneficial effects of drain holes.

In May, 1953, Well "B," which had been idle since 1939, was redrilled with drain holes in the oil zones. Six laterals averaging 70 ft long were drilled from 3539 to 3710 ft depth. Two inch slotted tubing prepacked liners were run in two of the drain holes after drilling was completed. No adapters were used to insure that the mouth of the

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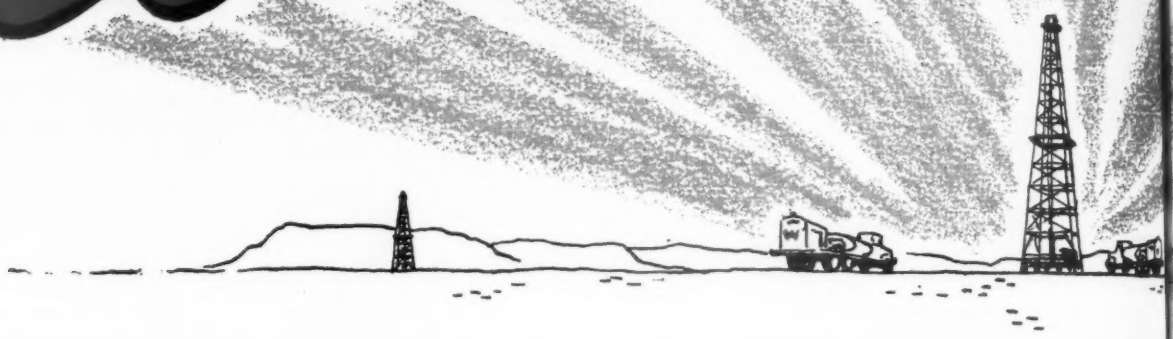

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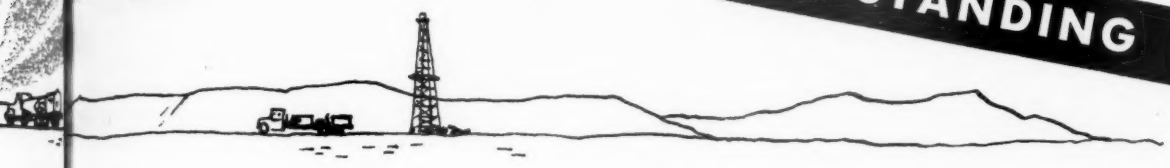

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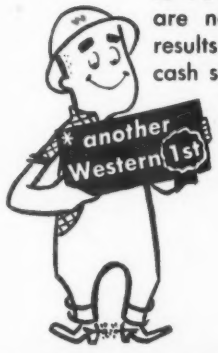

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drain holes stayed open. A 5½-in. prepacked liner was set in the vertical bore and the well was put on the pump. It produced at an average rate of between 30 and 22 bbl of oil per day for four months. In October the well sanded up and the liner collapsed. The liner was pulled and two new laterals were drilled at 3525 and 3550 ft depth. Prepacked tubing liners with adapteres were run into both of these drain holes and in the main bore. No accurate production figures are available from this well but from the evidence of production before the liner collapsed it is believed that this will be as successful a recompletion as Well "A."

Well "C" was a new well drilled from the surface of this lease in September, 1953, in an undepleted area between adjoining wells. Six drain holes 75 ft long were drilled in the oil zone. Directional surveys were made on two of the laterals. The first hole deviated 57 ft horizontally from the main bore attaining a maximum angle of 111 deg on bottom. Drain hole number 2 increased drift at the rate of 1 deg 20 min per ft to reach a maximum angle at bottom of 112 deg. It bottomed 60 ft from the main bore. Both holes were horizontal after 61 ft of hole had been made. The directional alignment of both holes was very good; both of the courses turned slightly to the left. Prepacked tubing liners 68 ft long equipped with adapters were set in each drain hole. The ends of the adapters extending into the main bore were milled off and a prepacked liner was run in the main bore. The first two months production of this well totaled almost 1900 bbl. The daily average was between 31 and 32 bbl per day. A spinner survey was run opposite the producing zone and special checks were made at the mouth of each drain hole. The results were not totally conclusive but the survey showed that oil was definitely entering the main bore from two of the laterals.

The company operating this lease is very well pleased with the increased production from drain hole drilling on these wells. If strippers producing 5 bbl per day can be redrilled with laterals to produce 30 to 35 bbl of oil per day for a considerable period of time, the recompletion can be very profitable. More redrilling of this type is in progress at present and a recompletion program including most of the wells is contemplated. Much credit is given to the modern prepacked liners fitted with adapters that are being used to keep the laterals open. It would be ideal if the adapters could be mechanically joined to the vertical liner but no simple process has been evolved at the present time.

Wilmington Field

Eight redrilled wells have been completed with various amounts of drain holes drilled in the oil zone by one company operating in the Wilmington field. The reservoir consists of from 600 to 700 ft of loose, poorly cemented, fine to medium grained oil saturated sand. The reservoir is depleted at the present time since the original exploitation of these leases began in 1937. Many of these wells have produced in excess of 100,000 bbl of oil. Due to the nature of the reservoir, sand trouble is a common occurrence and contributed largely to failures in four of the wells. All liners are either prepacked or flow packed after they are in place.

A whipstock was set at 2380 ft depth in Well "E," the fifth well, and it was redrilled from there to 3583 ft depth. Four 50-ft drain holes were drilled from 3175 to 3380 ft. The holes were oriented to start in all four quadrants and three were surveyed. The horizontal plan of the surveys showed that each hole had started in the desired direction and had described a long right hand curve to bottom. Drain hole liners of perforated pipe 4-in. in diameter and 48 ft in length were set in three of the laterals. The perforated pipe was torch cut with four lobes at short intervals to make the liner flexible. Each liner was run to bottom, consequently two ft of the mouth of the drain hole nearest the main bore was left unprotected. A 5¾-in. prepacked liner was set in the main bore. Previous to the redrill this well had been yielding 15 bbl of oil per day. After the rework it produced 46 bbl for the first 25 days. This decreased to a steady production of 35 bbl per day at the present time. The depleted oil zone was exposed to the drilling mud and water for almost three weeks during this recompletion which probably reduced the yield of oil.

In June, 1953, Well "F" was redrilled from 2524 to 3540 ft depth. Since 1937 when the well was first drilled it had produced over 300,000 bbl of oil. Four 68-ft laterals were drilled in the depleted sand from 3304 3470 ft depth and all surveyed. Although the original plan was for each lateral to branch out in a different quadrant it was found that they all bottomed in a southwesterly direction. The holes were separated vertically a sufficient distance, however, that drainage should have been good. Two of the drain holes were lined with prepacked tubing. Unfortunately, these liners were about 6 ft shorter than the holes in which they were set so the mouths of the holes were left unprotected. Two-inch slotted tubing was covered with a one-inch layer of fine gravel held in place with mesh screen. Tests were made at the surface which proved that

there was no necessity of cutting the tubing to make it more flexible. It was bent at the bottom to assist it in entering the mouth of the hole and was lowered into the holes successfully.

This well, which yielded 15 bbl per day before the redrill, averaged 52 bbl for the first month after it was put back on the pump. It has averaged 44 to 46 bbl of oil per day ever since. This reworking operation was simple and not expensive, the drain holes very evidently were drilled out sufficient distance to tap new oil sources, and the holes probably have remained open making the venture a financially successful one.

Well "G" pumped 5 bbl of oil per day before it was reworked. In July, 1953, it was redrilled from 2520 to 3525 ft depth. Four drain holes which averaged 72 ft in length each were drilled in the producing zone between 3245 and 3460. Three of the holes were lined with special prepacked tubing. A soft metal adapter was attached to the inner end of the liner. This adapter was about four ft in length and tapered from about 8-in. diameter at the open end to the size of the tubing where it attached to the liner. The length of liner and adapter was such that the adapter fit snugly into the mouth of the drain hole preventing the sand from plugging the liner. The end of the adapter protruded into the main bore and was milled off with a mill run on the drill pipe after the liner was set. An ordinary prepacked liner was set in the main bore. The well was put on the pump and produced at the rate of 73 bbl of oil per day for the first seven days. Production in barrels per day has averaged as follows: August—39 bbl, September—35 bbl, October—32 bbl. Obviously the gain in yield has been considerable since the cumulative production of this well since it was drilled in 1937 has been 150,000 bbl of oil. The recompletion of this well with drain holes should pay out rapidly and will show a considerable profit in a limited length of time.

Well "H" was redrilled with a drain hole completion in October, 1953, after having produced over 300,000 bbl of oil since it first was drilled in 1937. Six 75-ft laterals were drilled in the producing zone and all the holes were lined with gravel-packed liners equipped with adapters. These were the same type liner as run in Well "G." This well had pumped 8 to 10 bbl per day from 1947 to the date it was redrilled. The first production was 51 bbl per day and it is anticipated that the settled production will be between 30 and 35 barrels. This well will show a substantial profit from drainhole drilling.

The operator considers that the last three wells show definite promise that drainhole drilling can benefit the production of wells redrilled in the depleted sands at Wilmington and intends to continue the redrilling program. Probably one change in technique which is significant is the use of prepacked drain hole liners that line the hole to the main bore. The adapter prevents the plugging of the liners with sand as has probably made many of the unlined or partially lined drain holes ineffective.

In December, 1950, and continuing on until August, 1951, five wells operated by a major company were recompleted at Wilmington with lateral drain holes. All of the wells were drilled originally in 1937 and some had already been redrilled once. As each well was redrilled lateral drain holes were drilled at different levels in as many as four producing sands between 2950 and 3500 ft depth. An average of 7 holes was cut in each well varying in length from 30 to 80 ft long and averaging over 50 ft. After the laterals had been completed the 6⅛-in. main bore was opened with a wall scraper. When it was possible the lateral drilling tools were run back into the drain holes and they were circulated clean. In about half the cases it was found impossible to re-enter them.

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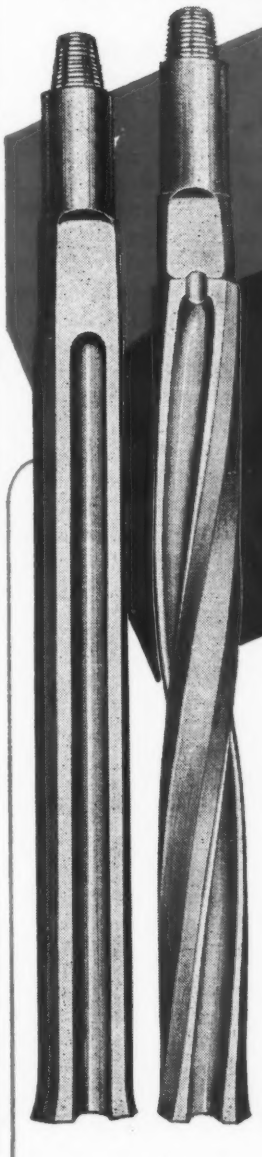

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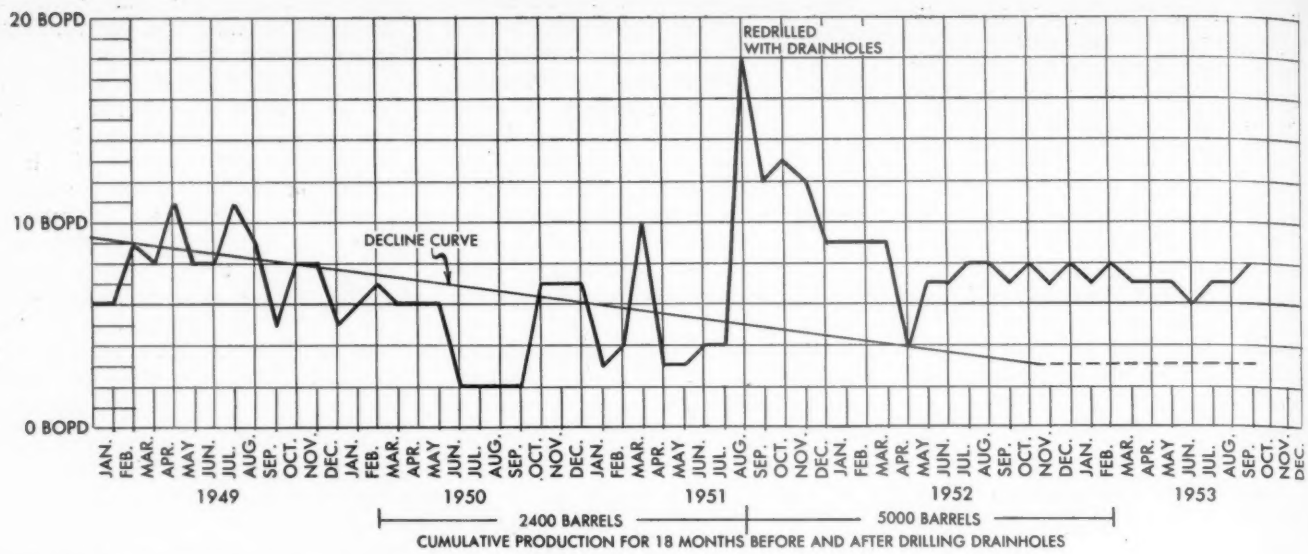


CHART NO. 1. Production curve on well in Edison, California, field recompleted with drain holes which doubles the yield of oil while reducing the rate of decline.

The main bore was completed with a slotted liner flow-packed with gravel. No liners were installed in the drain holes. Wells were produced with varying results. Average daily production varied between 80 and 125 bbl of oil after they were put on the pump. None of the wells showed any great increase over what might have been expected from an ordinary redrill and completion in the same location on the structure. However, in two cases the decline curve has been reduced considerably from the rate maintained before drain holes were drilled. The producing company estimates that the experiment has paid out but feels that results would have been much better if the laterals had been lined since they are convinced that the drain holes did not remain open for any length of time due to the extremely bad sand conditions in this field.

One Wilmington field operator gave the following data on three wells completed with drain holes in the oil zone. All wells produced 16 to 17 deg oil from about 3600 ft.

A new well was drilled in November, 1951, in an area where older wells had been producing since 1937. Eight drain holes averaging 50 ft in length were drilled in the oil sand and were lined with slotted liners filled with gravel. The vertical liner set in the main bore was flowed-pack with gravel. Initial production was approximately 160 bbl per day for the first year but the well now has declined to an average daily production of 120 bbl. This is a considerable production increase over wells ordinarily redrilled in this field since their initial production averages from 60 to 70 bbl per day and settled production is 40 to 50 bbl of oil.

A redrilled well on another lease recompleted with drain holes is now producing 54 bbl of oil per day. In November, 1952, a casing whipstock was set and a thousand feet of hole redrilled after which one 50-ft and one 28-ft lateral was drilled in the oil sand. Liners packed with gravel were run to protect the laterals and a prepacked liner was set in the main bore. An adjacent well on the same lease was redrilled at the same time but no drain holes were included in the completion. This comparative well produces only 20 bbl of oil daily. It is obvious that laterals drilled in the first well have been a very sound financial investment in this case.

Another well was redrilled with three 50-ft laterals drilled in the completion during November, 1952. Laterals were kept from sanding up with liners filled with gravel and a prepacked liner was set in the main bore. Before recompletion with drain holes the well produced 15 bbl per day; today its average production is 50 bbl.

This production experimentalist was enthusiastic in his endorsement of lateral drilling and recommended the universal use of liners considering that the soft sands in the Wilmington field would soon clog unprotected drain holes.

Brea Canyon

A major company was confronted with a problem they considered might be solved by drainhole drilling. In this field the productive beds lie at angles between 70 and 90 deg from horizontal. This condition coupled with low permeability parallel to the bedding made production difficult. Vertical drilling did not yield the amount of oil to be expected so several wells were slant-drilled to cut through the beds at an angle. An attempt was made to drill a directional well at about 25 deg drift to bottom at the intersection of the lowest part of the productive zone and the oil-water contact. Since all oil produced is from gravity drainage this was the best lo-

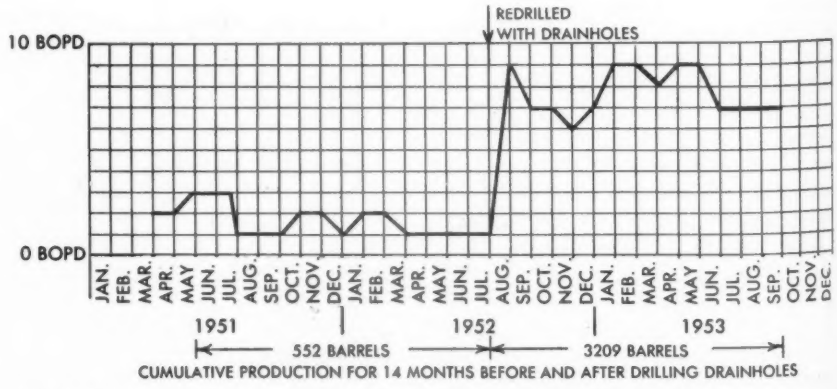
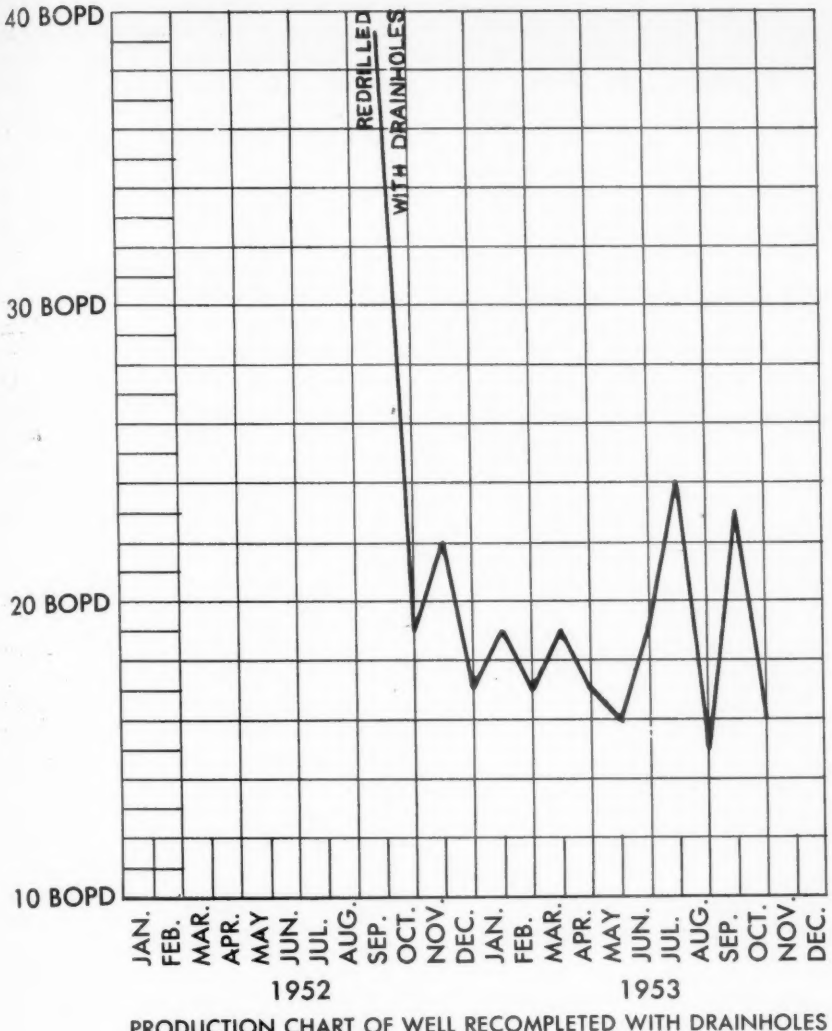


CHART NO. 2. Increase in production on a California well recompleted with laterals. Note that decline is not apparent since the redrill.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10 BOPD
REDRILLED WITH DRAINHOLES
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
1952
1953
PRODUCTION CHART OF WELL RECOMPLETED WITH DRAINHOLES
WHERE AVERAGE WELL ON LEASE IS PRODUCING 5 BOPD

CHART NO. 3. Since recompletion this well has produced 5300 bbl of oil more than the average well on the lease.

cation in which the well could have been bottomed. Unfortunately the estimation of this point was incorrect, since the water was higher than was anticipated. The well was plugged and two lateral drainholes were drilled with the idea of penetrating the productive zone to bottom. Two holes, one 55 ft and the other 66 ft long were drilled to accomplish this. Surveys made on the holes on their completion showed that the laterals had failed to penetrate in the desired direction and to increase angle as expected. No benefit was derived, therefore, from lateral drilling in this instance. With the further development of lateral drilling tools since these holes were drilled however, it is believed that drainholes could be drilled to benefit operators in similar situations today.

Signal Hill

There is considerable activity on the west flank of Signal Hill by independent operators in completing wells with drainholes at the present time. New wells drilled to the Brown Zone show definite benefit from lateral drilling. Most of these wells are completed with six drainholes drilled in two stages of three holes each. The 50-ft laterals radiate out from the mainbore equal distances apart at a depth of approximately 4300 ft. Most of the wells completed in a conventional manner with a vertical bore only average from 25 to 35 bbl of oil per day. Those with drainholes are good for a ten barrel increase and do not seem to decline as rapidly as the wells conventionally completed. Operators estimate that the cost of drilling laterals is only $3000 to $3500 per well including rig time and service charges. Since the additional oil produced is worth about $20,000 in the value of the well, drainholes pay out quickly. Oil sand is sharp and hard in this zone, dulling a bit in 80 ft of drilling but the penetration rate is good —drainhole drilling averages two days rig time since no liners are run in the laterals. A slotted liner is set in the mainbore. It is expected that all wells drilled in this area in the future will be completed with drainholes.

Summary

After checking the details of some 70 wells in which laterals have been drilled, it is obvious that few definite conclusions can be drawn. Since many of these wells were completed with early types of lateral drilling tools and techniques which were in the experimental stage, results were inconclusive. Many factors are involved beside the drainhole drilling. Methods of completion of the main bore itself were incorrect in some cases. In many instances drainhole drilling was used as a last resort when all other methods had failed. Comparisons between wells on the same lease often are difficult to analyze since oil reservoirs show great variations within themselves. Many of the well records examined were not complete or were not exact due to lack of accurate means for checking of production from individual wells. Some facts do stand out clearly, however, and a number of suggestions can be made from knowledge gained in this study.

The mechanics of drilling laterals from a mainbore is highly developed. Operators may drill drainholes with the assurance that little mechanical difficulty will be encountered.

Control of the angle and direction of the course of the hole is at its highest development. The radically different types of drainhole drilling tools give the operator a choice of whichever type he considers best for his specific problem.

Drainholes may be aimed upward to a specified angle and extended outward more than a hundred feet at this chosen angle or made to drill at angles above horizontal. Drainholes may be directed in a surprisingly straight course considering the extreme flexibility of the drill stem used.

Without a doubt more wells are being newly completed or recompleted with drainholes at the present time than has ever been done previously. At present this activity is greatest in the softer oil sand formations of California. Few operators are willing to spend money for services which are not effective so it must be assumed that they must be benefitting from drainholes. As more laterals are drilled, tools will be perfected and their use will become less expensive to operators. This will interest operators who have been reluctant to drill laterals because of the expense.

Surveying of drainholes is always desirable. In order to evaluate the efficiency of the laterals, knowledge must be obtained as to the distance and direction in which the drainhole deviated. In complex geological situations it is

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essential that the laterals be drilled in a definite direction or their value is doubtful. The comparatively few drainhole surveys made in the last three years have aided greatly in the development of drilling tools. As laterals deviate further from the well, problems of subsurface trespass will arise which can be settled only by an accurate survey of each hole after it is drilled.

It is possible that in many cases drainholes that deviate further from the well would have been of greater benefit. Early tools did not offer the operator the opportunity of drilling long laterals. Present day tools have penetrated over a hundred feet from the well bore and are capable of drilling much further. With longer laterals more undepleted sand should be tapped.

A combination of lateral drilling with other recovery aids may offer a solution to the problem of added oil recovery. Lateral bores can be selectively acidized for best results in limestone reservoirs. Fracturing of drain holes should release oil otherwise unrecoverable.

Whenever similar results can be obtained by drilling a number of laterals rather than sidetracking the main bore, drainhole drilling should be employed. All drainhole drilling is done in the producing sand itself so each foot of hole drilled represents new productive sand exposed. Use of a casing whipstock, milling of casing, setting of additional casing, etc. is eliminated. Much valuable rig time is saved by drilling laterals since the average set of six 50-ft holes drilled in wells on Signal Hill is done in two days time or less.

The possibility of using drainholes as an aid in repressuring or water flooding has not been explored. It is possible that a number of applications can be made in this field which would make drainhole drilling advantageous.

Whenever laterals are drilled in depleted oil sands it is essential that light crude oil or oil emulsion should be used as a circulating fluid to prevent clogging the productive formation.

In laying out a program where drainhole drilling is contemplated it is much to the operator's advantage to initially complete the well with laterals. The cost of later rigging up to bore the laterals is saved if they are included in the original completion.

A number of laterals are preferable to one or two drilled in an individual well. Obviously, if the laterals are not lined the whole effect of the laterals may be lost if only a few are drilled. If a number are dug, a few may sand up but the others still benefit the production. Time spent in rigging up to do the drilling and in moving off the well is

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the same regardless of the number of laterals drilled.

Each company that digs laterals in the original completion or redrills with them later would benefit greatly if accurate records were kept or comparison with wells completed by ordinary means. Since drainhole drilling is a completion practice which in most cases can be expected to pay out over years of production rather than a quick recovery process, accurate records of production are essential. Determination of the efficiency of lateral drilling on the lease concerned is of importance in future planning.

A number of operators whose wells have been laterally drilled have emphasized the failure of their operations as due to not running a liner in the drain holes. This one factor probably is the cause of more failures in drainhole drilling than any other. Especially is this true in unconsolidated sands in California fields where much sand is produced with the oil. Muskat in his excellent work on the physical principles of oil production discusses the effect of a sanded liner on the production capacity of a well. He proves that a sand column of permeability as high as 200 times that of the pay sand will reduce the productive capacity of the well to only 34 per cent of its original value. Since this is true in a vertical bore it should be true of laterals too. Since the cost of the liner and its installation is small compared to the complete cost of drilling the drainholes and it is so essential that the laterals be effectively kept open to flow oil to the main bore, liners should be used in all laterals.

It is noted in numerous examples in this paper that the holes had sanded up even before the lateral drilling operation was completed. Probably the best type of liner is gravel-packed tubing equipped with an adapter that serves to keep the mouth of the drainhole open. Ultimately it is hoped that a liner will be developed that can be removed and replaced or at least cleaned out periodically. In fact one operator has suggested that drainholes be drilled off bottom as the well is deepened. After a small gage lateral has been completed it would be reamed to full gage and a large gravel-packed liner set. These liners would be of sufficient size so that they could be cleaned out whenever it was necessary.

As more drainholes are drilled practical ideas and suggestions will present themselves as specific problems are encountered.

Acknowledgments

The author wishes to express his appreciation to all of the operators who gave so freely of their time and data on drainhole drilling and permitted examination of their production records. The critical review and suggestions of these men has greatly increased the value of this article. Acknowledgement also is given to J. B. Murdock, Jr., consulting petroleum engineer, for gathering the data and assisting in the preparation of this paper. All photographs and drawings were made by the Eastman Oil Well Survey Company.

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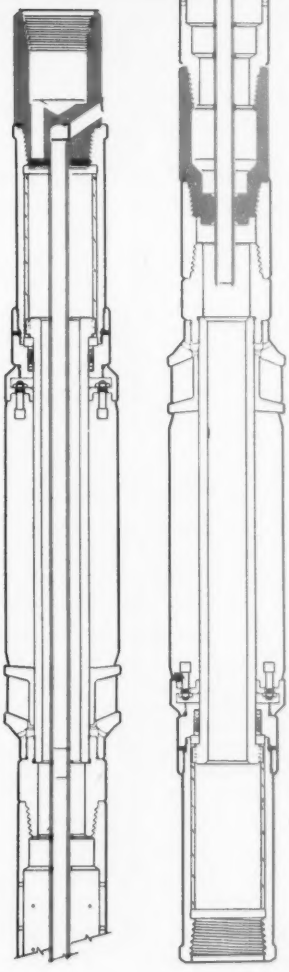

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WESTERN KANSAS

Cathodic Protection of Treating Equipment

Operating life of emulsion reduction equipment substantially extended through the installation of magnesium anodes

W. C. KOGER

EXPERIENCE with cathodic protection of treating equipment in Western Kansas has proved that the life of steel vessels can be substantially increased when protection is applied properly. Protected vessels have been in service for 4 years without any evidence of corrosion in areas where the life of an unprotected vessel was approximately 5 years. Cities Service has 50 vessels under protection in Western Kansas and periodic inspections indicate that all the equipment is in excellent condition.

The cathodic protection program currently being used by Cities Service Oil Company in Western Kansas was developed by extensive field testing and some of the information obtained from these installations may be of interest to those contemplating a similar program in this area. It is also quite probable that cathodic protection of treating equipment is applicable to other areas that are experiencing similar problems in the production of sour crude.

The initial installation of magnesium anodes was made in a 6 ft by 20 ft gunbarrel treater after several coatings had failed to protect the vessels. At the time this test was started, there was very little information available on the use of cathodic protection in treating equipment so this test was designed to be as severe as possible. The vessel chosen for the test was severely corroded and it was necessary to repair the fire tube before the vessel could be put back into service. Two bare 50-lb anodes were placed approximately 3 ft apart, on 8-in. by 8-in. by 16-in. concrete blocks in the center of the treater, directly underneath the fire tube. The lead wires were brought out through 2 small packing glands in the cleanout plate and were welded to the side of the vessel.

These anodes were allowed to deplete themselves without external resistance in the circuit. Current readings were taken weekly during the first part of this test and Fig. 1 is a plot of these readings. The first reading taken after 6 months service indicated the anodes were practically consummed and the treater was drained and inspected. This test was considered to be of 180 days duration at an average current density of 14 ma per sq ft.

When this treater was opened for inspection, approximately 12 in. of loose scale was found on the bottom of the treater and large sheets of scale were found hanging from the sides of the vessel. Considerable scale was found on the fire tube but was mostly soft and porous and did not seem to seriously affect the heat transfer to the fluid. New layers of scale had formed under the sheets of loose scale so that no bare metal was exposed to the brine. This scale was composed largely of carbonates and was almost completely dissolved in dilute hydrochloric acid.

A thorough inspection of this vessel did not reveal any active corrosion, even though it was in very poor condition at the time anodes were installed. Approximately four years have elapsed since this test and the treater is still in service and has not required any repairs during that time.

Approximately 12 lb of magnesium remained at the time the treater was inspected and, based on the theoretical 1000 amperes per pound of magnesium, the anode efficiency was roughly 37 per cent. Forty per cent anode efficiency is currently being used to calculate the life of the anodes and has proved to be satisfactory.

Several additional installations were

The Author

W. C. Koger is head of the corrosion and oil treating section, oil production division of Cities Service Oil Company. A graduate of the University of Arkansas, Koger joined Cities Service's refinery research division in 1944. After serving for two years in the Navy during World War II he was transferred to the oil production division as corrosion engineer in the West Kansas division where he dealt with the problems of some 1100 wells. Koger was transferred to Bartlesville, Oklahoma in 1954 where he assumed his present position.

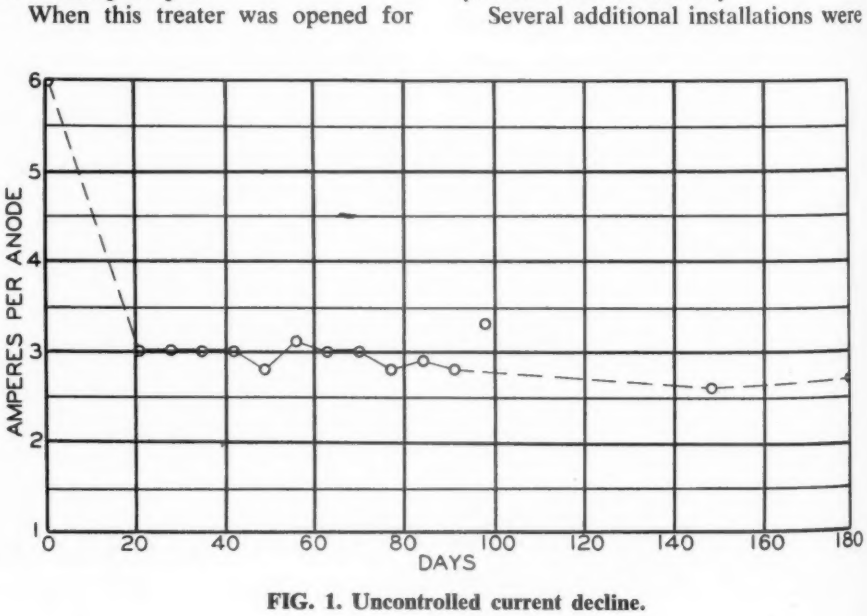


FIG. 1. Uncontrolled current decline.

EXCLUSIVE

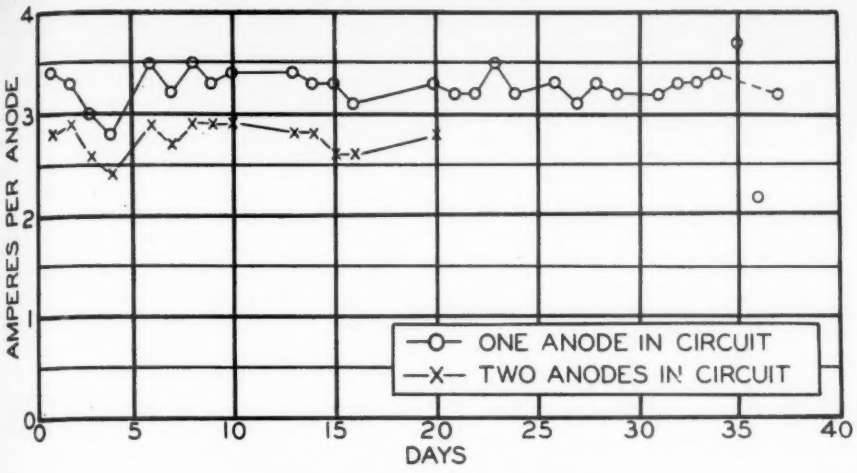


FIG. 2. Interference between anodes.

made in an effort to obtain as much information as possible about the use of anodes in this service. Slight changes were made in each installation to evaluate the various factors. The information presented here is based on experience with 27 installations over a period of 33 months.

Anode Location

There was some question about the good judgment of locating the anodes near the bottom of the treater. It was suggested that a better current distribution could be obtained by locating the anodes near the center of the water section. Placing the anodes on blocks on the bottom of the gunbarrel treater, however, has several advantages over other locations. These advantages are:

1. The anodes can be changed without having to enter the vessel.
2. Special shaped anodes are not required.
3. Decomposition products from the anodes, as well as scale that breaks off the fire tube, can be removed when the anodes are changed.
4. The cleanout plate is an ideal place to bring the lead wires outside the vessel.

After considering these advantages, it was decided that the location would be used but special attention would be given to the shielded areas of the vessel during inspections. To date no evidence has been found to indicate that there is any more tendency for corrosion to occur in the shielded areas than in any other portion of the vessel. Also, there has been no definite indication of corrosion under the concrete blocks.

Anode Interference

The possibility of interference between the anodes was considered. Fig. 2 shows the interference between two 50-lb anodes placed approximately 4 ft apart in the bottom of the 10 by 20-ft treater.

Very little consideration has been given to this factor as all of the installations are putting out more current than is required for protection. When sufficient magnesium is used to keep anode changes to a minimum, it is very doubtful that interference will enter into the picture.

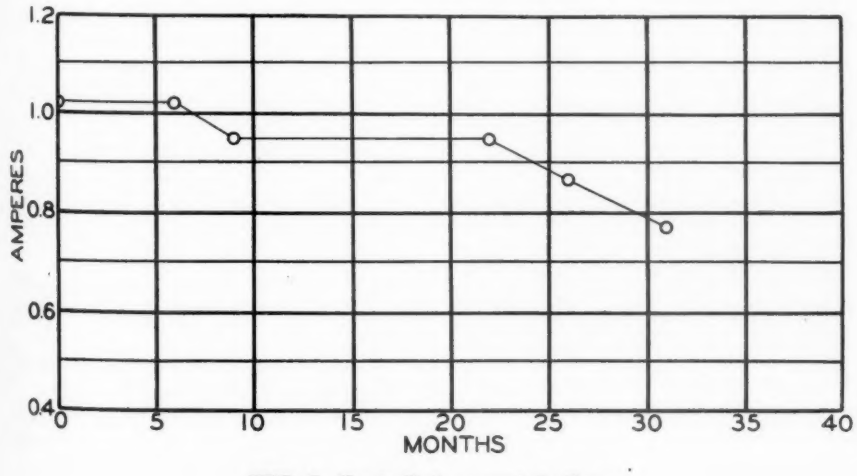


FIG. 3. Controlled current decline.

External Resistance

The current decline from the anodes in the initial installation was very gradual, after polarization, and it was assumed that external resistance in the circuit would substantially increase the life of the anodes. Fig. 3 is a plot of the regulated current output from two 50-lb anodes in a 4 by 18-ft treater for a period of 31 months. The current requirement for this treater was very small as compared to the large treaters and it was assumed that any detrimental effects that might develop in controlling the current from the anodes would be found. Over this period of time the current density declined from 7.4 to 5.6 ma per sq ft. The vessel was found to be in good condition at the conclusion of this test and the anode efficiency remained essentially the same.

Current Density Required

As the object of this program was to protect treating equipment, considerable attention was devoted to determining the current density required for protection. It was obvious from the initial test that 14 ma per sq ft would give adequate protection and the additional tests were designed to determine the minimum current requirement. In the next 27 installations, the current density was varied from a high of 10.9 ma per sq ft to a low of 1.85 ma per sq ft. Table 1 shows the results of the current density studies. At least 3 reasonable conclusions can be drawn from these data:

1. A current density of five milliampere per square foot should give adequate protection.
2. The current requirements in some areas will be greater than in others.
3. A decline in current density below the five milliamperes per square foot

TABLE 1. Results of current density studies.

Vessel no.	Condition	Current density—ma/sq. ft. Initial	Fina	Test period months
1	Good	10.9		18
2	Good	10.9		19
3	Good	7.4	5.6	33
4	Good	6.8	4.1	14
5	Good	6.8		17
6	Good	6.3	4.6	20
7	Good	6.0	5.0	16
8	Good	6.0	3.7	27
9	Good	6.0	4.2	23
10	Good	6.0		27
11	Good	6.0	4.0	23
12	Good	6.0	5.4	22
13	Good	5.1		18
14	Good	5.0		17
15	Good	5.0		23
16	Good	5.0		13
17	Good	5.0		18
18	Good	4.9		16
19	Good	4.8	2.5	17
20	Good	4.3	4.0	24
21	Fair	4.2		10
22	Fair	3.8		16
23	Good	3.7		13
24	Good	3.6		15
25	Good	3.4	3.1	14
26	Good	2.5		33
27	Fair	1.85	1.15	30

FIG. 4. Anode record.

Lease ..... Location .....
Type Vessel ..... Kind ..... Size .....
Area to be protected ..... sq ft No. anodes used .....
Date anodes installed .....
Left anode: (at time of installation) O.C.P. ..... Amps .....
Right anode: (at time of installation) O.C.P. ..... Amps .....
Left anode: (immediately before installing resistance) O.C.P. ..... Amps .....
Right anode: (immediately before installing resistance) O.C.P. ..... Amps .....
Date Resistance installed ..... Current density ...../sq ft
Left anode: Amps ..... Volts ..... Calc. Resistance .....
Right anode: Amps ..... Volts ..... Calc. Resistance .....

Operating Data

Date	Anode	Volts	Ohms	Calc Amps	Remarks

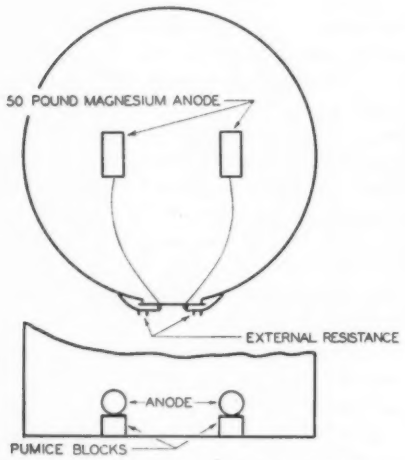


FIG. 5. Magnesium anodes in treater.

considered necessary for protection for short periods of time is not serious.

Decreasing the current density has eliminated the large amount of scale that was found in the first treater protected with anodes. A thin layer of scale is desirable and is being used as an indication of the current requirement. The absence of scale is usually accompanied with minor corrosion and the current density is increased. Conversly, if a thick layer of scale is found on the vessel walls, the current density is reduced.

Cost of Protection

Cost of protection with magnesium anodes varies somewhat between installations. The area to be protected, the amount of magnesium used and the method used to change the anodes are the major factors to be considered. Two 50-lb anodes have been used in all the vessels considered in this report; therefore, the cost to protect a large vessel would be greater than for a small vessel. We are currently considering the use of two 100-lb anodes in large treaters to reduce this cost.

A rather inexpensive method of changing anodes is for the pumper to float the oil out of the treater with the lease production. The lease is then shut down and the treater drained. After this is done, the anodes can be changed and the lease put back on production with a minimum amount of down time.

We believe a reasonable estimate of the cost to protect a 10 by 16-ft gunbarrel treater with two 50-lb anodes would be $40 per year or about 10 cents per square foot of area protected per year. This cost can probably be reduced by using two 100-lb anodes.

Procedure

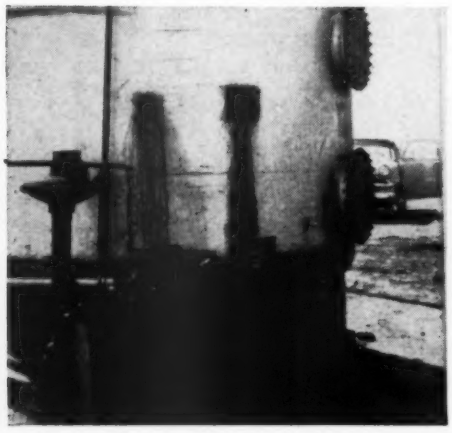
The procedure used to protect a vessel is to place the anodes on blocks on the bottom of the treater and bring the lead wires out through stuffing boxes in the cleanout plate. The lead wires are welded to the vessel and two or three days allowed for the vessel to polarize after the water section has been filled by normal production.

After the vessel has polarized, external resistance is placed in the circuit to reduce the current to the amount required for five milliamperes per square foot of area to be protected. When the resistance is placed in the circuit, the voltage drop is measured and the resistance calculated. For future readings, the current output can be calculated from the voltage drop and it is not necessary to break the circuit. A record is kept of each installation similar to the one shown in Fig. 4.

Conclusions

In Western Kansas treating equipment can be effectively and economically protected from the severe corrosion experienced in the production of Arbuckle brine with magnesium anodes. To obtain the maximum benefit from the use of anodes, the following precautions should be observed:

1. Use a sufficient amount of magnesium to insure a reasonable life for the installation.
2. Regulate the current output for a current density of five milliamperes per square foot of area to be protected to obtain the maximum life from the anodes.
3. Take periodic readings to be sure that the installation is functioning properly.
4. Use silver soldered lead wires to minimize lead wire trouble.
5. Inspect the vessel when the anodes are changed to determine if the current should be increased or decreased. ★ ★ ★



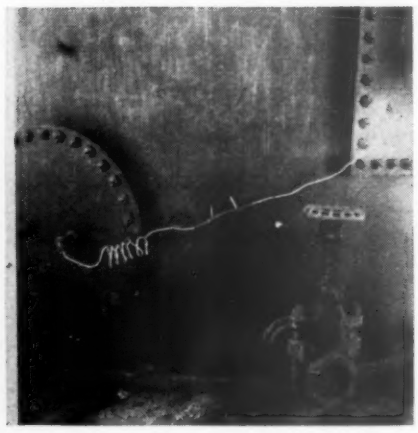


FIG. 6. After one year's service the interior of this vessel was severely corroded. Extensive patching was necessary (two of the patches are visible in the left photograph). Anodes were installed in April, 1952, and no further leaks have occurred.

FIG. 7. Lead wire from one anode to body of vessel. Stuffing-box, Nichrome resistance, and weld are visible.

XUM

STRAIGHT HOLE DRILLING

R. J. Bromell

To the practical man engaged in drilling a well, the hole becomes "crooked" when he is forced to retard drilling as a means of keeping vertical deviations within contract limits. Throughout this article "crooked hole" will carry this same meaning since we are concerned with actual drilling progress and the effect of application of technical knowledge.

Special devices such as ribbed joints of pipe or drill collars and sleeve type or roller type stabilizers have been tried for many years to help drill straight holes. The results of using the various combinations of these devices were uncertain. Since so many factors between wells varied, it was not considered practical to study the wells as a group. Each crooked hole presented a problem to be solved as an individual case. In most cases the only way to drill a "straight hole" was to reduce the weight on the bit and consequently reduce the drilling rate.

Many things have been tried as a means to drill "straight holes" such as changing bit types, deleting teeth from bits, deleting cones, using limber members on the bottom of the drill stem, stabilizing, reducing hole size, and then reaming to the desired size, and running light weight and then suddenly increasing weight. With the exception of stabilizing, the effect of any of these methods is questionable and experience has shown that the results cannot be predicted or reliably repeated.

The approach to a crooked hole problem has changed from the old attempt to drill "straight holes" (small deviation angles) to that of drilling the most economical hole. Larger deviation angles are becoming more acceptable and better control of the hole makes it possible to drill with more weight in the crooked zones. This method has greatly reduced drilling costs. The method, as being used in many places today, was preceded by precise mathematical analysis. The cause of crooked hole and the effect of drill collar size, weight on the bit, stabilizers and related factors have been analyzed mathematically. This information makes it possible to approach the crooked hole as a scientific problem instead of another unplanned experiment.

Through the proper application of the available technical data on crooked holes, drilling costs can be reduced. The amount to be saved will vary with the individual case or locality. When provided with a knowledge of the area in question a practical man can now plan to drill with confidence. The well to be drilled can be classified according to its severity and the best known methods can be employed to combat the situation. Prior planning, utilizing available data, is now possible and is indeed essential to economically drilling through crooked zones.

Keep in mind that crooked holes cannot be economically eliminated but a change in prevalent concepts of trouble causing deviation angles will greatly reduce the cost of such holes.

*Great Western Drilling Company, Midland, Texas.

Basic Concepts

In this study it is assumed that the drill collars will lay on the low side of the hole as the hole deviates from vertical. The drill collars are assumed to act as a pendulum from the point of contact with the wall of the hole to the bit; this length, supported only by the bit, tends to swing toward vertical. This tendency applies a lateral force on the bit which causes the bit to cut sideways and acts as a "hole straightening" force. The amount of this force can be increased by (1) lengthening the "pendulum" section, (2) increasing the weight of the "pendulum" section, or (3) by increasing the angle from vertical. These variations are illustrated in Fig. 1.

Illustrations are simplified for the purpose of setting forth the principle forces acting on the bit. The forces which determine the hole deviation and drilling progress are (1) the weight on the bit, (2) the reaction of the formation tending to deviate the hole, and (3) the straightening effect of the drill collar "pendulum" trying to return to vertical. These forces are shown in Fig. 2.

If the forces are in lateral balance, the hole angle will continue unchanged as is shown at Point A. A change in deviation must be preceded by some change in the direction or strength of the forces at the bit, as occurs at Point B. These forces can be thrown out of balance by increasing or decreasing the bit weight, by changing drill collar size, by stabilizing or by a change in formation characteristics.

In a near vertical hole, such as shown in Fig. 2 to Point A, the bit moved downward since the lateral components of the forces were in balance. When the bit reached Point B

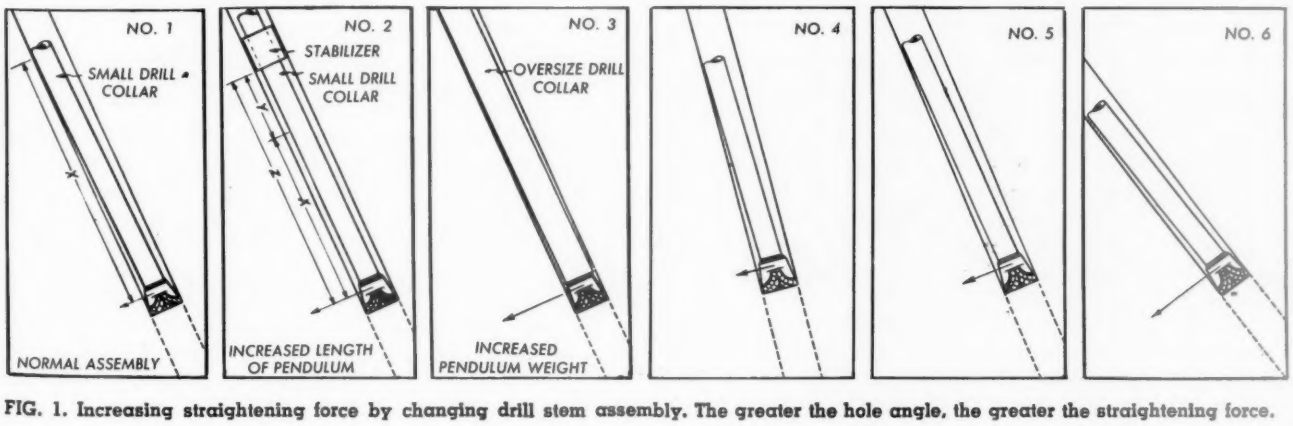


FIG. 1. Increasing straightening force by changing drill stem assembly. The greater the hole angle, the greater the straightening force.

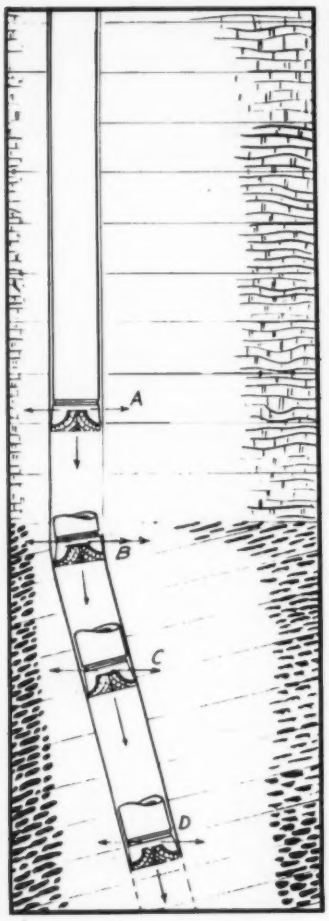


FIG. 2. Increase in deviation and establishment of new equilibrium condition after change in dip.

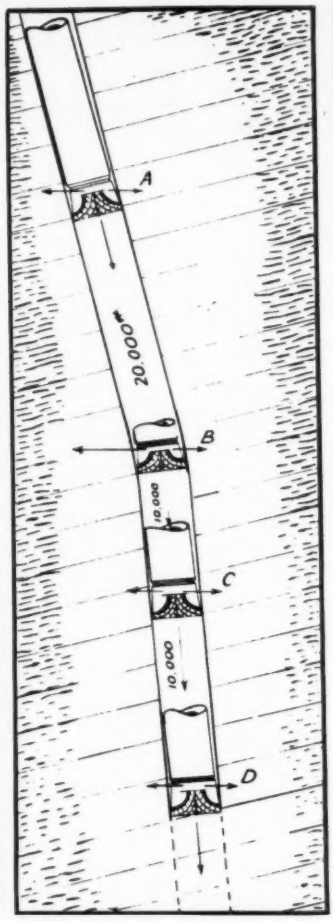


FIG. 3. Reducing hole deviation by reduction in weight on the bit.

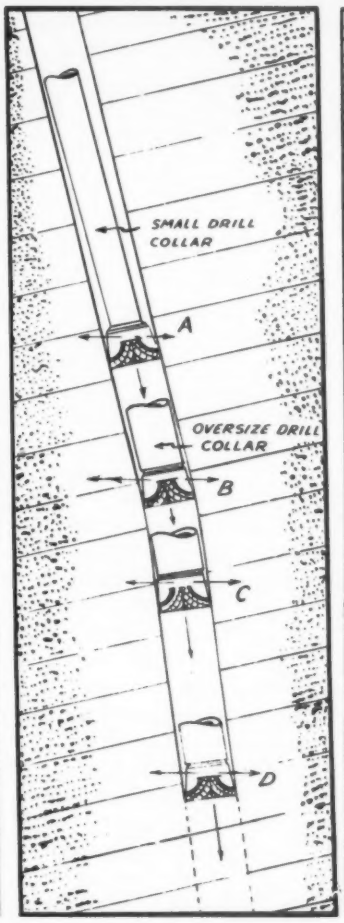


FIG. 4. Reducing hole deviation by increasing pendulum weight.

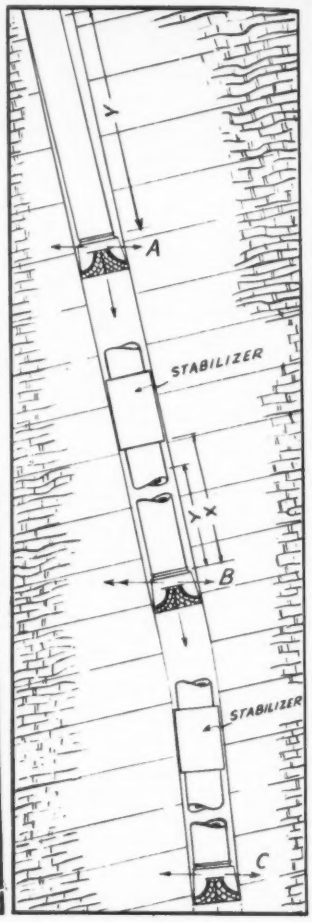


FIG. 5. Reducing hole deviation by increasing pendulum length.

the horizontal reaction of the formation tending to push the bit away from vertical was greater than the straightening force of the drill collars and the hole started to deviate from vertical. By the time Point C was reached the straightening force of the collars had increased as the hole angle increased until the lateral forces were again balanced. The section from Point C to Point D is straight though inclined, which means that a state of equilibrium has been reached and no change in angle will take place until the lateral balance is changed.

A change in hole deviation obtained by a change in weight is illustrated in Fig. 3. As the weight was decreased the lateral forces became unbalanced, the pendulum force of the drill collars being greater than the horizontal reaction of the formation, and the hole started to straighten. At Point C the lateral forces once again balanced and the hole remained straight while drilling progressed to Point D. In this case drilling progress will be retarded as bit weight has been decreased in order to reduce hole angle.

Substituting a larger drill collar will give the same effect. It increases the pendulum force of the drill collars and reduces the hole angle until a state of equilibrium is reached, as shown in Fig. 4. At Point C the forces have again become balanced and the hole will continue at this angle. Note that in this case drilling progress is not retarded as the bit weight remains constant, but reduction in angle is accomplished by increasing the pendulum effect of the drill collars.

A similar result can also be obtained by using a stabilizer with small collars to raise the point of contact of the drill collars with the wall of the hole, as shown in Fig. 5. The pendulum length is shown as Distance Y without the stabilizer and is increased to Distance X by use of a stabilizer. The increase in the length of the collars acting as a pendulum increases the force tending to return the collars to the vertical position. As the hole is drilled from Point B to Point C the deviation decreases and the lateral balance is again established. Again, drilling progress has not been retarded, as the hole angle has been decreased without reduction of the weight on the bit.

Rapid Changes in Hole Deviation

Production departments of some oil companies, which are producing from wells with large deviation angles, no longer consider hole deviation in itself to be detrimental. Some confusion and misinformation still exists among those not familiar with such practices and the old standard of 3 or 5 deg maximum deviation are still misleading criteria.

Production or drilling troubles caused by sudden changes in direction frequently have been blamed on high deviation angles. Wells drilled to a graduated deviation limit which increases as depth increases are costing operators thousands of dollars unnecessarily.

A careful study of producing wells with high deviation angles and controlled rates of change should be made and contract procedures examined to determine if the present specification of maximum hole angle is penalizing the producer. Strict adherence to small deviation angles can penalize the producer in two ways. Forced light weight to maintain small angles raises the cost per foot and the producer must eventually pay this increased cost of drilling. In cases where the hole angle rapidly approaches the contract limit, the producer pays for and sometimes insists on drilling practices which result in a dogleg being formed

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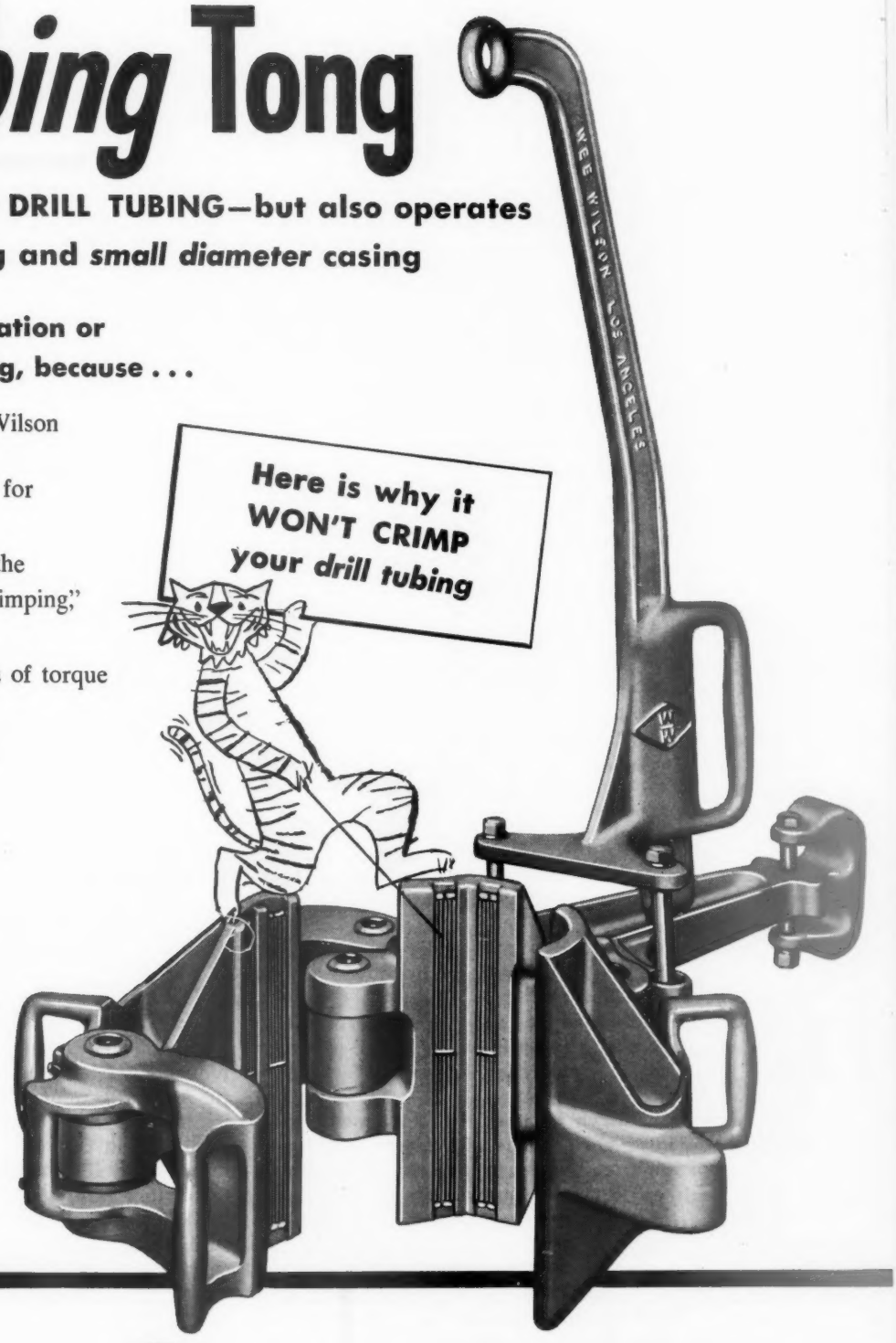

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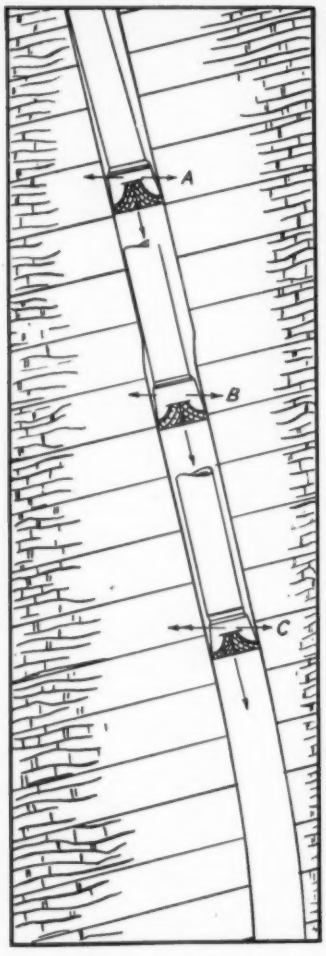

FIG. 6. Formation of a dogleg by rapid reduction of weight on bit showing eventual reduction in hole angle.

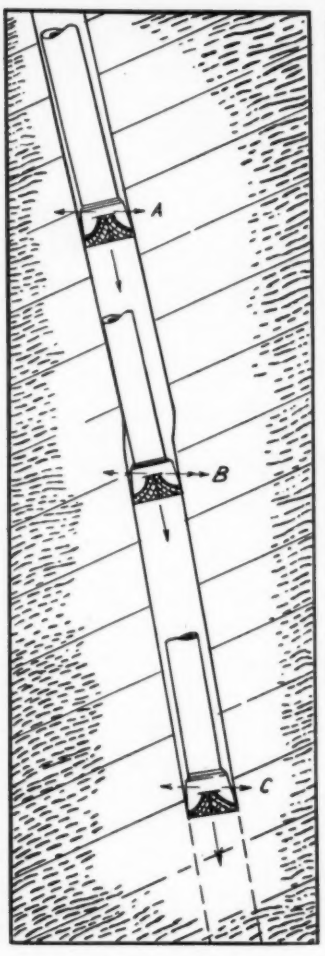

FIG. 7. formation of a dogleg in a more severe crooked hole zone showing slight increase in deviation angle.

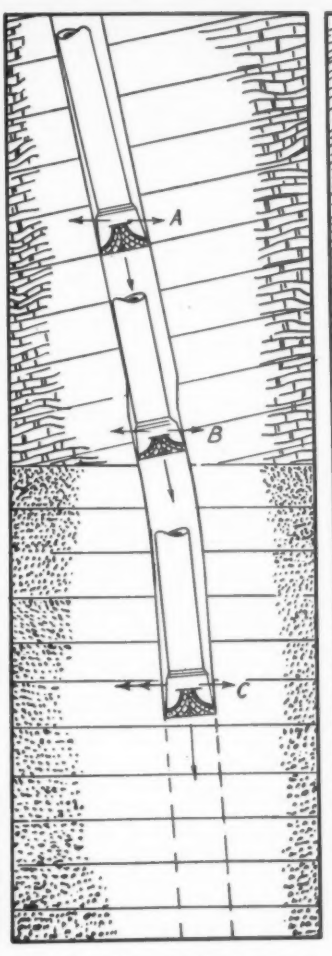

FIG. 8. Hole straightening after increase of bit weight near bottom edge of crooked hole zone.

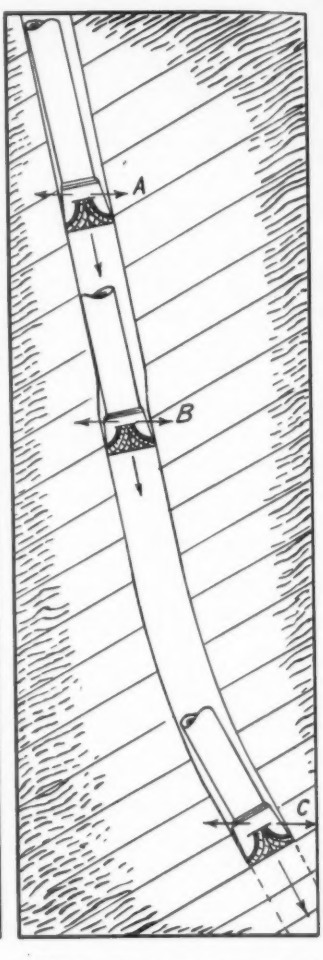

FIG. 9. Effect of increased bit weight when a considerable section of crooked hole zone remains to be drilled.

through a diligent effort to keep the hole straight. Deviation is held within limits only by a drastic reduction of weight.

A misunderstanding as to what actually causes trouble in a producing well has led to a false feeling of security in maintaining small deviation angles. Certainly, deviation angle is important but it is by no means the only important factor. Various factors have been under study and new methods to define "crooked hole" for contract purposes have been proposed.[2]

Fig. 6 has been drawn to clarify what happens when abrupt changes in weight are made to control hole deviation. It is apparent from this illustration that even though the desired hole angle was maintained, the well bore was not as trouble free as might be expected. In a hole approaching contract limit, Point A, a large reduction in weight has been made, a dogleg formed, and a smaller deviation reading obtained at Point B. Reduction in hole angle has stopped at this point because the collars touched the wall of the hole at a point close to the bit and the straightening force is lost. The hole will continue to drill at this angle until Point C, when the pendulum length of the collars increases enough to produce a straightening force which will overcome the formation reaction. The hole then gradually straightens until the equilibrium condition is reached.

Fig. 7 illustrates a variation of this condition in a more severe crooked hole zone. When the dogleg was formed and the drill collars contacted the wall of the hole near the bit, the pendulum force was lost and sufficient formation reaction existed to actually increase the hole deviation slightly. If the hole is permitted to progress the formation's force will be overcome by the increase in pendulum effect of the collars and a new equilibrium will be established.

The new deviation established will be greater in Fig. 7 but in both Fig. 6 and Fig. 7 better results could have been obtained without the hazard of the dogleg by a gradual reduction of bit weight. Often the tendency is to lighten the weight even further if a deviation survey is made showing the hole angle to be increasing slightly after the dogleg is formed in the case of Fig. 7. This practice costs even more money since a reduction in weight will generally slow the drilling rate.

Many field men can remember places where a hole was straightened by "fanning bottom" and then "throwing the weight to it" after recording an indication that the hole is beginning to straighten. In several cases which have been examined the situation paralleled that illustrated in Fig. 8. After a long period of various experimental operations which carried drilling progress to near the lower edge of a crooked hole zone, light weight operation was tried and the dogleg was formed.

After getting a slight reduction in hole angle the weight was increased to several thousand pounds per inch of bit diameter. Drilling progress immediately increased and when Point B was reached the formation had changed and lateral force of the formation was very much reduced.

The hole angle reduced to near vertical and the hole is

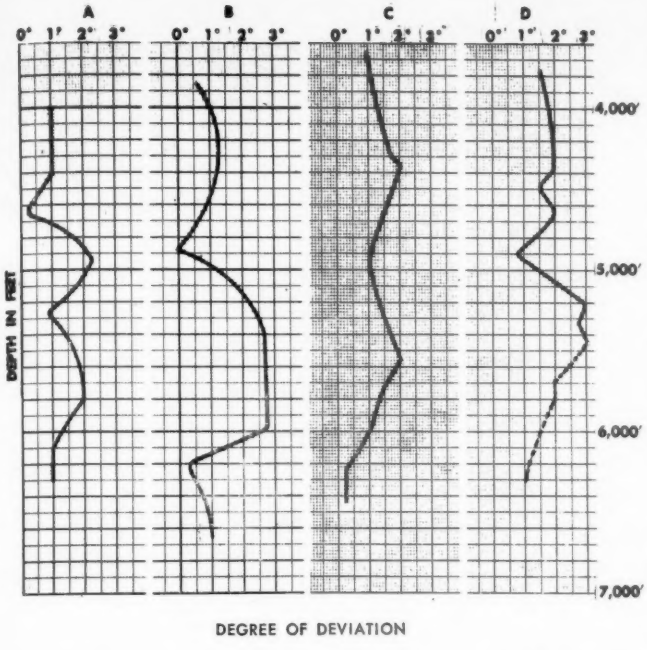

FIG. 10. Plotting known data to determine extent of crooked zones.

said to have been straightened by weight. This was the actual case in several instances examined.

Weight failed to straighten the hole illustrated in Fig. 9. This situation was similar to that shown in Fig. 8 except that a considerable section of the crooked zone remained and the hole angle went to 9 deg.

Knowing when the formation will change is apparently the trick to straightening a hole by increasing the weight. This can sometimes be planned and the drilling rate profitably increased while approaching the formation of lesser dip.

Size of the dogleg and the rate of change of hole deviation will be much less for large drill collars as they will touch the hole wall sooner as the bit cuts sideways, as shown in the illustrations.

Solution of Actual Drilling Problems

Many cases where theoretical data has been confirmed by actual results are available and a few have been selected to illustrate certain types of problems and how they were solved.

Learn all possible about the area in preparation for drilling crooked hole; the depth, thickness and severity of crooked zones. After this has been done the best equipment for the job can be selected, the program planned and the hole can be drilled as economically as possible for the conditions which exist.

Example 1: Two rigs were moved into a new field where limited information was available. The records available did not show any severe crooked hole sections so no preventive measures were taken. Slight crooked hole was encountered with Rig A, while Rig D found the same zone was severe and difficult to drill. Fig. 10 was drawn to show depth versus hole angle for Rig A and the other two wells which had been drilled. This graph was made only to show the depth at which deviation changes could be expected and ignores all other factors.

It was noted that in each of these three wells the deviation angle increased at 5200 feet and in each case returned to near vertical at 6100 ft. The well Rig D was drilling was plotted next to the other curves and it too showed an increase in angle at 5200 ft. It was then reasonable to assume that it would start to lose angle as it approached 6100 ft. The weight was gradually increased from 5000 lb to 20,000 lb in the lower portion of the crooked hole section and the drilling rate was increased from 2.56 to 13.2 ft per hr.

By predicting where the hole would straighten, heavy weight could be run through a zone when normally light weight would have been carried. Starting the heavy weight program at the maximum deviation of 3 deg as indicated by the broken line in Fig. 10, Well D, the hole had returned to 2 deg at the end of the first bit run and continued to reduce angle to 1 deg as drilling progressed.

These first two wells (A and D) required an average of 62 bits, 60 days and 720 rotating hours. With proper planning and accumulated knowledge of the area wells are now drilled with 40 bits, 42 days and 535 rotating hours, a saving of 22 bits and 18 days.

From the Woods and Lubinski charts it was determined that 8¾-in. hole using 8-in. drill collars would be more economical to drill than the 7⅞-in. hole, 6-in. drill collar combination used on the first two wells. Calculated on a basis of 3 deg maximum deviation, 15,000 lb was carried with the 6-in. collars in 7⅞-in. hole and 34,000 lb could be carried with 8-in. collars in 8¾-in. hole at the same deviation. Actual drilling in this field with 35,000 lb 8-in. collars and 8¾-in. hole produced a maximum deviation of 2¾ deg, which was reached after most of the section had been drilled. The 35,000 lb weight was used to drill the entire section and the hole was free of doglegs.

In this area electric logs and sample descriptions have been used to correlate the wells and when crooked zones are approached in drilling, reamers are placed just above the bit to retard the rate at which the hole gains angle. It is accepted that the hole will be allowed to approach the maximum contract angle since the most economical drilling rate will be at the maximum weight usable to establish equilibrium just under the contract limit. To retard the rate at which the hole gains angle permits more hole to be made under heavy weight conditions before weight must be reduced to establish equilibrium near the contract limit.

No set rule can be made to say when reamers should be used or stabilizers moved in the string. Proper use of these tools comes from field analysis experience. An excellent knowledge of the crooked zone formation is necessary to properly evaluate results. The presence or absence of reamers can have a profound effect on drilling angle and rate of change of this angle.

Three crooked zones exist in each hole drilled in this area and similar solutions have been applied to each zone. The savings mentioned are cumulative for all zones and not for the one zone shown in Fig. 10.

Example 2: Two wells drilled in Gaines County, Texas, showed a marked tendency for the wells to deviate at approximately 6300 ft. The most severe section came at approximately 7800 ft but the entire interval from 6300 ft to 8400 ft had to be drilled with light weight. An analysis was made of the hole size, weight on bit, drill collar size and hole deviation through the section in question. The Lu-

TABLE 1.

Well	Hole size	Collar size	Weight 1000's	Maximum deviation	No. bits through zone	Days through zone
A	7-¾"	5-¾"	22	4°	63	66
B Calculated	8-⅝"	5-¾"	18	3°	58 4 Dia	45
C	8-¾"	8"	47	4°	?	30
Actual C	8-¾"	8"	40	3°	42	32

XUM

binski and Woods curves were utilized and an estimate made as to how much faster the well could be drilled with oversized collars.

Table 1 presents a tabulated account of what was done:

Using oversize collars and drilling at maximum angle saved 13 days and 22 bits. The most rapid rate of penetration will be obtained when the hole angle is near the contract limit. To reduce the weight and straighten the hole only results in slower penetration and greater cost per foot. Why drill with light weight and maintain 1 or 2 deg when the drilling rate can be increased while maintaining and controlling deviation at 3 or even 4 deg? Once the equilibrium angle is obtained the hole is under control; that is, to increase weight slightly increases the hole angle and conversely, to decrease weight decreases the hole angle.

Contractors actually did establish equilibrium in the first two wells listed in Table 1. They continually reduced weight and found that they had to maintain a large angle and comparatively heavy weight to drill the hard formation. Several runs were made with the same weight and the hole remained at the same angle which means the hole was in equilibrium. The small collars offered a small straightening force and consequently the weight had to be reduced. The Lubinski and Woods charts offered a means of calculating the effect of using larger drill collars and increasing the pendulum effect. The use of larger drill collars permitted more weight on the bit while keeping the hole in lateral equilibrium at the same deviation angle.

Example 3: A well in the Rocky Mountains was being drilled with 6-in. drill collars in a 9-in. hole. The formation was known to dip 30 deg. At a depth of only a few hundred feet the hole was off to 4 deg and the weight had been reduced to 4000 lb. Every known bit type and construction was used, including two cutter, three cutter, four cutter and diamond bits. In 24 days 1747 ft were drilled, using 40 bits, including diamond bits. 4 deg deviation was still held with 8000 lb weight. It was calculated from the Woods and Lubinski charts that with a 5 deg deviation and 8-in. drill collars, 17,000 lb could be run. Permission was obtained to try this procedure.

Two 8-in. collars were run immediately above the bit with 6-in. collars completing the string, and 17,000 lb was placed on the bit. Eight days later 857 ft had been drilled with 13 bits and the hole was at 4¼ deg. At this point the operator chose to try to straighten up the hole. The 8-in. collars were removed and light weight operation resumed. The final result at this writing was the establishment of a 5 to 5½ deg deviation angle. 23 bits had been used to drill 1019 ft. Bit usage had been higher due to the practice of reducing the hole size and then reaming to full size.

Table 2 is a presentation of the progress on this well:

TABLE 2.

Depth from	to	Feet drilled	Bits used	Days	Feet per bit	Cost/ft @ $40/hr Rig time
1091	2838	1747	40	24	42.15	19.50
2838	2696	857	13	8	65.5	12.20
3696	4715	1019	23	17	44.3	20.15

Example 4: Stabilizers are being used to increase the straightening force of the drill collars by increasing the distance between the bit and the point at which the drill collar contacts the side of the hole. The distance the stabilizer is placed above the bit depends upon the hole size and the collar size. When trying to obtain the maximum straightening effect with 6¼-in. collars in a 7⅞-in. hole the stabilizer was found to be very effective at 68 ft above the bit. Unpublished theoretical data shows the optimum distance above the bit to be 73 ft.

While drilling a crooked 7⅞-in. hole with 6¼-in. drill collars the hole was in lateral equilibrium with 15,000 lb of weight at 3 deg. A stabilizer was placed in the string and the same weight carried on the bit. The hole now stabilized at 2 deg. A weight of 20,000 lb was placed on the bit and the hole stabilized at 3 deg. Several changes were made in the weight and stabilizer arrangement and it was found that 5000 lb additional weight could be carried on the bit when properly using the stabilizer.

Example 5: All theoretical work must of necessity assume uniform bedding planes and formation dip. No mathematical formula can be used to evaluate the forces expected by fractured formation. Since a great amount of crooked hole is caused by fractured formation, it is necessary to assume an equivalent uniform case.

For example, if a fractured zone is encountered while drilling and the hole reaches a state of lateral equilibrium at 5 deg with 8-in. collars in an 8¾-in. hole with 15,000 lb of weight, predictions can be made as to what results will be obtained if certain changes are made. Treat the information the same way as any other set of field data and enter in the charts. Care should be exercised when working with a hole of this nature since rapid changes in direction are possible.

On one such well as mentioned above, the hole deviation changed 2 deg in about 25 ft. The sudden change, although the total deviation angle was small, indicated that a severe crooked hole condition could be expected. Weight was reduced to minimize the rate of change and even with 8-in. collars in 8¾-in. hole the deviation angle reached 8 deg in about 150 ft. Several bits were run and the hole stabilized the same as in other crooked holes.

The operator decided to core and it was noted that the lower 2 ft of the core was free of the cracks and secondary deposition which marked the upper portion. After reaming down the core hole more weight was placed on the bit and as expected, the hole started to straighten.

By carefully reducing weight and controlling the rate of change as much as was practical the hole was permitted to reach a comparatively high deviation angle for West Texas. This was necessary in order to carry enough weight to drill the hard formation.

The hole was drilled over 1000 ft beyond the severe crooked zone with no evidence of dragging.

Summary

It has been shown that various methods of drilling crooked holes, all based on straightening the hole, are questionable in their effectiveness and certainly can prove to be expensive practices. A planned scientific approach to the crooked hole problem through the use of Lubinski and Woods charts can in most cases result in lower drilling costs. Although great improvement is made in many cases there are still cases where the conditions are so severe it is necessary to drill with light weight. It is now possible to know if you are drilling in such a formation. If it is severe, drill it as such and be satisfied, for experimenting will only cost more money and may lead to trouble.

Crooked hole can best be handled through planning. Check to find out where the hole will go off, how severe it will probably be, when the hole will straighten, and what size hole must be drilled. Proper selection of drill collar size and placement of stabilizers and reamers greatly reduce the cost per foot.

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2. "The Need for Definition of a Crooked Hole" by R. B. McCloy, a paper presented at the Southwest District API spring meeting, March, 1954.

* * *

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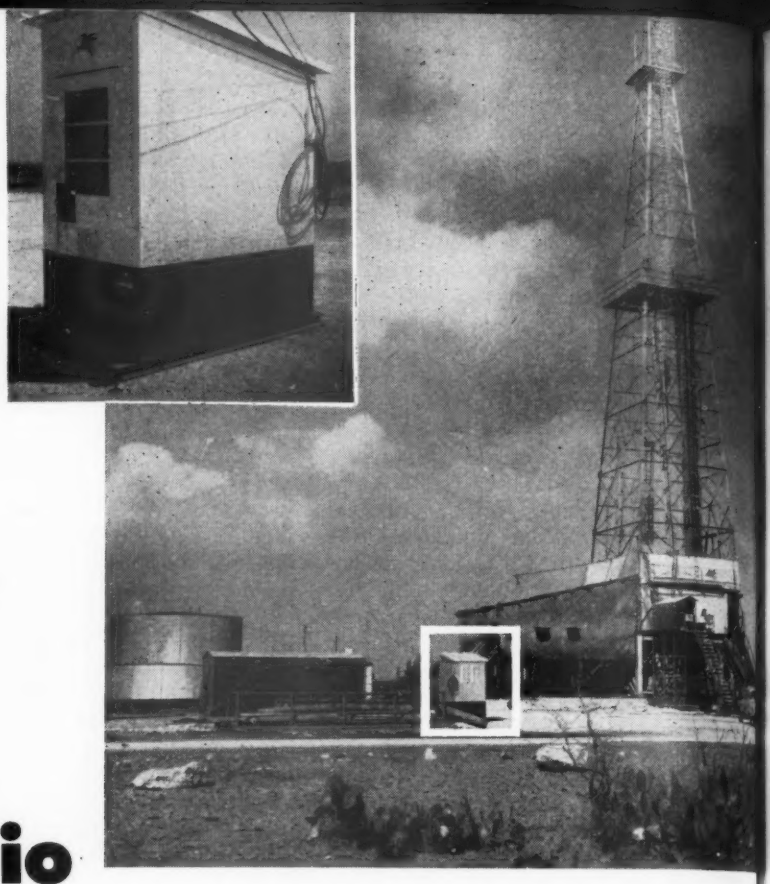

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6. **Reports from rigs and wells come in on time.**
7. **Drillers and pumpers can reach the boss whenever necessary.**
8. **Of inestimable value in emergencies—get immediate action—no waiting for someone to drive to the nearest office.**

What radio means in saving supervisors' driving time is graphically illustrated by district superintendent C. H. Samples: "Before we had radio, I have left my home at 2 a.m. and did not get back before midnight—driving 600 miles, all within a small area, in order to be in touch with happenings. Radio allows me to work normal hours, yet I know what's happening better than ever before."

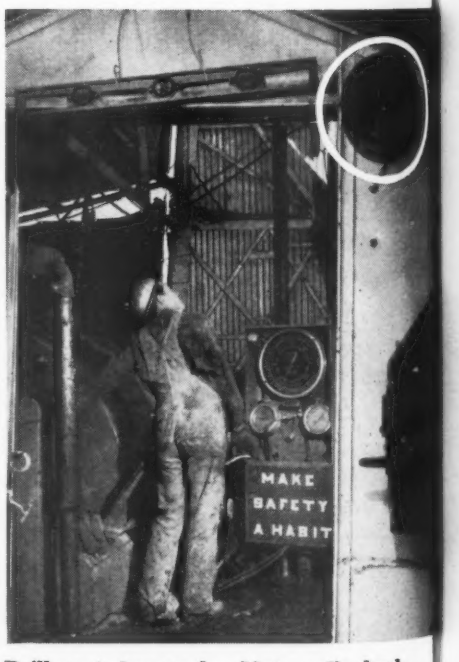
How It Started

Magnolia's most intensive deep drilling activity today is in the Pegasus field in Upton and Midland counties of Texas. The Pegasus discovery assumes considerable importance because of the number of producing horizons and because the principal producing zone yields a high quality crude. At the present time Pegasus production averages some 13,000 bbl daily, approximately 23 per cent of the company's gross production from the entire Permian basin.

In Magnolia's operation all drilling is supervised by the producing department of the company. Some of the drilling is done by contractors, much by Magnolia itself—depending upon the size of well, availability of rigs, etc. To tie the entire drilling and producing activities into a compact, efficient operation, two-way radio is employed as an effective communication medium.

The Radio System

The main radio station is located at the Pegasus district office and con-



Driller at drawworks. Note radio loudspeaker mounted at right, above doorway in driller's dog house.

EXCLUSIVE

*Editor, *Communications News*, Published by Engineering Products Division, Radio Corporation of America, Camden, N. J.

XUM

sists of a 70-watt transmitter. Semi-portable base stations are located at several "camps" or offices within the district. The same type base stations are also installed at drilling rigs and at producing wells. In addition, mobile radio units are installed in the cars of all foremen and supervisors.

The Pegasus station radio is remotely controlled from two points: 1) the office, and 2) the home of the district superintendent. The office control has five extensions that permit all required personnel to converse with "camps," rigs and wells, and supervisors in cars.

The district superintendent can always be reached, whether he is in the office, in a radio car, or at home. Furthermore, he is always in touch with all operations by means of radio communication.

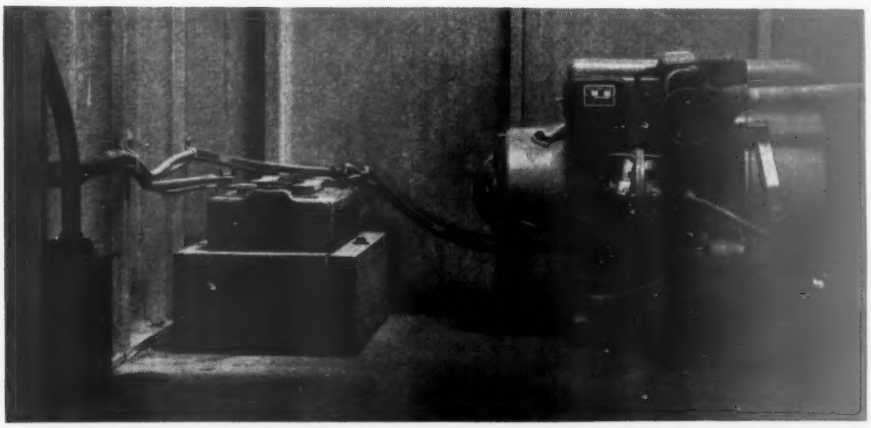
Main Station

The base station is installed in a 4 by 7-ft prefabricated steel building, on a concrete base adjacent to the antenna tower and within a stone's throw from the district office building. The radio is powered by the regular 110-v power supply and the installation includes an emergency power supply, consisting of gas-driven engine coupled to 110-v ac generator. Thus, it is ready to operate under all conditions. Should power lines fail or wire lines go down, the radio is always available to provide two-way communication.

The antenna tower is a 160-ft structure supporting a ground plane antenna. This provides 100 per cent coverage within a 50 mile radius and 90 per cent coverage at 100 miles radius. In other words there is consistent and

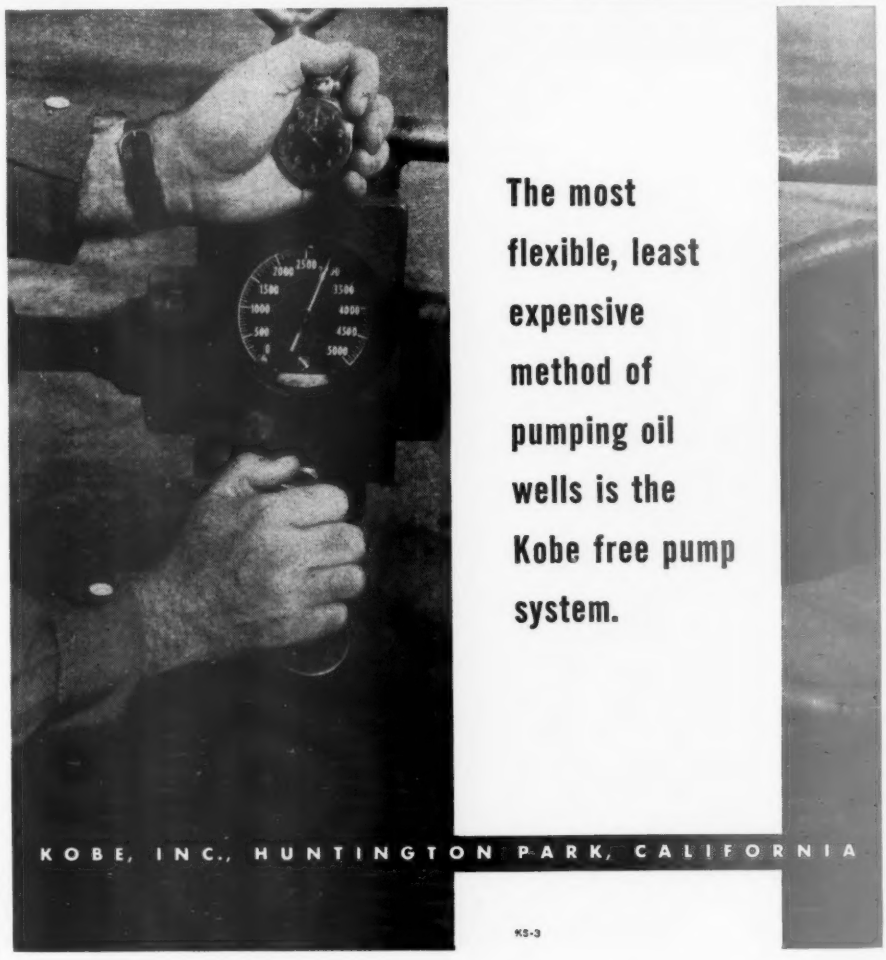
J. E. Middleton, assistant foreman, at driver area "camp" office of Pegasus District. Note converted 6-volt mobile radio.

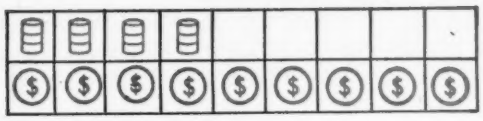
Driller R. W. Christian, at rig radio talks directly to office and to foreman in car.



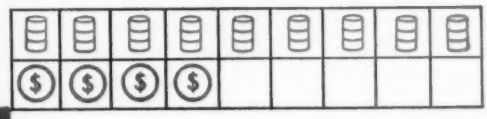
Battery and motor-generator combination power the 6-volt radio station at drilling rig.

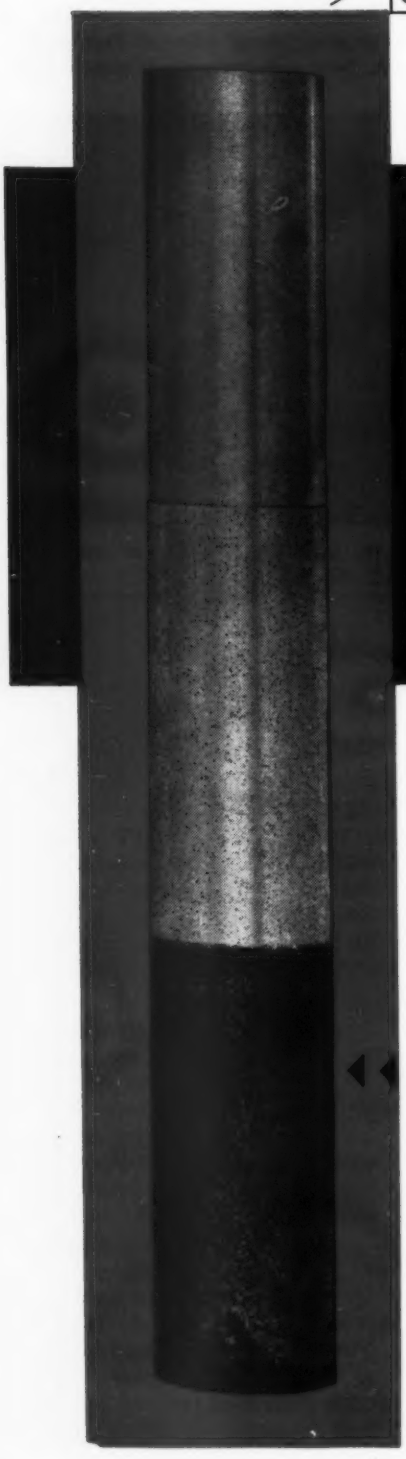
G. C. Rutherford, Pegasus field producing foreman, contacting office by mobile radio while at producing well.


The most flexible, least expensive method of pumping oil wells is the Kobe free pump system.
KOBE, INC., HUNTINGTON PARK, CALIFORNIA
KS-3



MORE PRODUCTION at LESS COST!





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PLUNGERS & LINERS

Used in thousands of pumps in practically every producing area and under the most severe deep oil well pumping service conditions, Pacific Pacilite liners and plungers have definitely proved their superiority. Longer liner and plunger life is assured without sticking or galling; the possibility of cracking or shearing is virtually eliminated. For further details on the Pacific Pacilite process write for Technical Bulletin #201.

The Pacific Pacilite process is a method of control etching the surfaces of pump liners and plungers to form a multitude of minute reservoirs that absorb and retain lubricants. This greatly increased lubrication allows closer fits between liners and plungers and relieves the plating tensile stress. Note dark, dull, rough finish characteristic of Pacilite processed metal. Center surface; .001" below finish; top surface: .005" below finish.

Pacific Pumps inc.
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DW—11

satisfactory communication over an area of more than 30,000 square miles.

Movable Stations

Radio stations on leases are housed in a transportable prefabricated steel structure, four by seven feet. This building is mounted on a steel sled, constructed from 4-in. "I" beams in the Magnolia shops. Because of the sled construction the shelter can be easily skidded along when necessary to move from one location to another.

The radio stations at rigs and wells consist of equipment originally designed for mobile application but adapted to fixed station use by Peake Communications, Inc., Abilene, Texas. The adaptation makes it possible to conserve space by use of a small unit and to make an economical installation. Standard 60-watt mobile units are employed. They are designed for use with and are powered by a standard 6 or 12-v automobile battery. In adapting them to use as fixed stations they are provided with a charging panel with automatic voltage regulator and meter for indicating state of, and maintaining battery that is in, charged condition.

When used at drilling rigs, they can be charged either by a standard automobile generator mounted on the drawworks or can be provided with a motor generator set. In the latter case the motor is powered by the 110-v supply from the drawworks and it in turn drives an auto generator to charge the battery. When used at producing wells, the battery is kept charged by a generator, powered by a gas motor that runs on either butane or natural gas.

The same type of radio is used at several camp offices in the district. It makes a small, economical installation that can be easily hung on a wall.

Antennas find a made-to-order tower at drilling rig installations. At wells and camp offices the antenna is supported by a wooden pole approximately 40 ft high. This provides a simple but adequate installation for communication within the entire district.

Mobile Radio in Cars

Field foremen have 60-watt mobile units installed in their automobiles, so that they can keep in touch with the activities they supervise even while traveling. The radio consists of a compact transmitter/receiver unit in a steel housing approximately 12 by 16 by 8-in. This unit is installed in the trunk of a car, and since it takes less room than a spare tire, there is sufficient space for tools and supplies. The controls, loudspeaker and microphone are mounted on the dash. The radio is powered by regular battery of the car.

Site of producing well showing pumper's dog house at left and radio dog house at right of pole.

Facilities Afforded by Radio

The Pegasus district covers 32 counties in West Texas but operations are centralized in an area within a 50-mile radius of Pegasus. Although there are no telephone lines, communications coverage of the entire area is easily achieved by use of two-way radio. Not only are rigs and producing wells in constant touch with the offices, but by means of mobile radio all three are also in constant touch with foremen traveling about in their cars.

The office works a 5-day week but since producing and drilling are "round the clock" operations, so is the radio system. Foremen and superintendents are always available via radio to handle emergencies.

How the Radio System Works

Magnolia employs a single-frequency radio system, operating on 49.18 mc. This means that the system constitutes one large party line over which everyone hears what everyone else has to say. By this means all personnel know what is going on at all times.

Cars are designated by call numbers such as T-1, T-2, etc. Stations have call letters assigned by the FCC. The main station is KKH-553 while the portable stations at rigs and wells have call letters KKH-434, KKH-435, etc. Each station or car is called by giving the call number or call letters and each transmission is ended by the final party signing off with his call.

Routine Uses for Radio

"Radio is an indispensable medium in all our everyday activities," asserts District Superintendent C. F. Stephenson. "We use it, for example, to keep in touch with our drilling operations. Progress reports are made by radio from the rig to the office and instructions are relayed to foremen from the office."

"It is also used for reporting production from producing wells. Pumpers use the radio stations on our leases to

In many areas . . .

Operators are finding that DIAMONDS REDUCE CORING AND DRILLING COSTS

FORMATION BIT DIA. (IN.)	TOTAL FOOTAGE	PENE-TRATION RATE	TOTAL COST	BIT COST PER FOOT	BIT LOAD POUNDS PER INCH	DRILLING RPM	CON-DITIONS FL. VOL.
WILDCAT FIELD, ROOSEVELT, MONTANA							
Shale, dolomite, lime, anhydrite 6"x2⅝"	1365 ft.	1-4 ft. hr.	$1575.00	**$1.15**	8,000-12,000	60-65	200-300 gpm
WILDCAT FIELD, CHEYENNE COUNTY, NEBR.							
Dakota and shale 6⅛"x3½"	700 ft.	4 ft. hr.	$1072.10	**$1.53**	8,000-14,000	60-70	200 gpm
BISTENAU FIELD, WEBSTER COUNTY, LA.							
Cotton Valley Lime 4¾" HSF	456 ft.	2.8 ft. hr.	$1563.70	**$3.43**	6,000	90-100	130 gpm
KILDARE FIELD, CASS COUNTY, TEXAS							
Shale, lime, sand 4¾" D.C. Drilling	565 ft.	3-4 ft. hr.	$1107.30	**$1.96**	6,000-10,000	80-120	120-130 gpm

Why not call the Christensen office nearest your location for recommendations for the drilling or coring problems you are encountering.

CHRISTENSEN DIAMOND PRODUCTS

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report to the foremen at their offices. Foremen can also radio the pumpers to give them instructions.

"Radio is used by our foremen while in cars to contact offices, rigs, and wells. They can arrange to have outside telephone calls made by the district telephone operator and can order service just as though they were in the office. They can control operations at rigs and wells just as if they were there on the spot."

Effectiveness of Two-Way Radio

"We have made a wise investment," affirms Mr. Stephenson, "in procuring a two-way radio system. Before we had radio, our men had to drive as much as 40 miles each day in order to phone in a report. When this is multiplied by the number of rigs and wells reporting, you can see that we save thousands of miles of driving each day. This means less wear and tear on our cars, saves time, and most important of all we can use our men for more productive efforts.

"Radio is very effective in emergencies. We had seen this demonstrated by some service companies that had radio, which we used before getting our own. Since there is no other means and since it is extremely important to us in these sparsely settled areas to have communication, the importance of radio cannot be overestimated."

Radio Procedure at District Office

The telephone operator receives each radio call and notifies the called party by phone, then the called party lifts the radio receiver and has direct two-way communication. Five radio extensions are installed in the Pegasus offices of:

1. District Superintendent.
2. Assistant District Superintendent.
3. Field Foreman.
4. Warehouse.
5. Production Office.

Radio employs the same type handset as used for telephone conversation and conversations are carried on in the same way.

The radio system[1] was installed[2] in September, 1952. It has proved so satisfactory in operation that numerous additions have been made since that time. It is serviced and maintained in top operating condition by the installing company.

The results of using radio are aptly summed up by division superintendent Harve Mayfield: "Radio saves time checking on places that need checking. Few jobs need constant supervision but there are always a lot to keep tabs on. The radio speeds up our operation by saving many miles of driving and many hours of supervisors' time." * * *

[1]RCA Equipment.
[2]Peake Communications, Inc., Abilene, Texas.

Penn State Awarded Research Grant

The Pennsylvania Grade Crude Oil Association has allocated $11,000 for petroleum production research in 1955 at the College of Mineral Industries of The Pennsylvania State University.

The non-profit association's board of directors at a meeting recently approved a 1955 budget for operation of the production research program, in operation since 1944. The petroleum studies at Penn State will supplement research conducted by the association's production research laboratory.

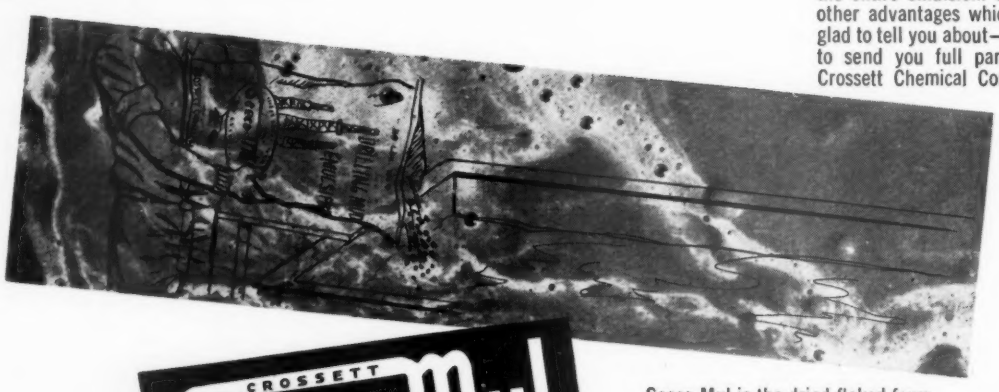
The Penn Grade group's production research technical advisory committee had recommended to the board that the 1955 allocation to Penn State be used entirely on projects related to an applied type of petroleum production research.

A possibility was seen that funds would be made available by the Commonwealth of Pennsylvania to continue fundamental research which has been under way for some time on use of electric logging in petroleum production.

Increase Drilling Rate With Less Drill Stem Torque

Better Lubrication • Lower Pump Pressure

Seeco-Mul effectively disperses the oil in emulsion muds which affords better lubricating qualities in the mud and allows faster drilling, reduces frictional drag of the drill string, and provides a higher velocity of the fluid on bottom. With good lubricating qualities in the mud, less drill stem torque is required, pump pressures can be lowered and more evenly sustained, and the bit stays cleaner. All of this means longer service life, too, for liners, collars, tool joints, bits, and drill pipe. Seeco-Mul is completely soluble in water and readily emulsifies Diesel or crude oils for use in sodium type or limed muds; in most cases Seeco-Mul efficiently tightens the entire emulsion. Seeco-Mul has a number of other advantages which your mud dealer will be glad to tell you about—or write to us; we'll be glad to send you full particulars without obligation. Crossett Chemical Company, Crossett, Arkansas.



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"MAKES A GOOD MUD BETTER"

An Editor Reports on

The Sonic Oilwell Pump

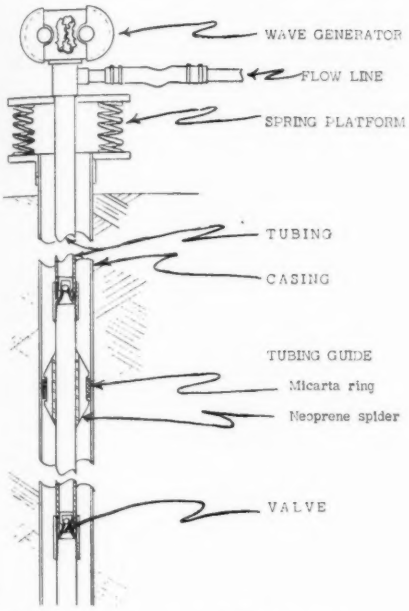

Fig. 1. Sonic pump installation uses conventional tubing string.

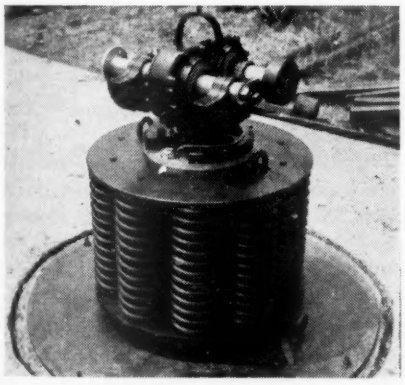

Fig. 2. Spring supported tubing hanger for sonic pump with mounted generator.

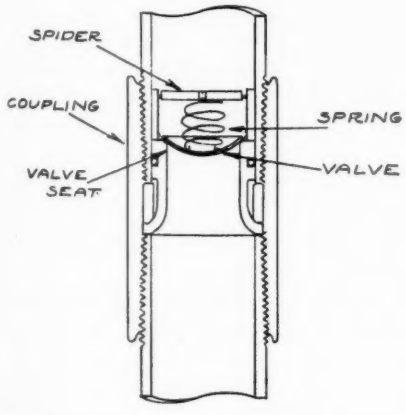

Fig. 3. Diagram of spring check which serves a valve in sonic installation.

Device shows promise of adding another acceptable method to industries means for lifting oil.

J. B. Stumm†

IN a previous issue an article was presented that described the basic fundamentals of operation of the sonic drill.* Experimentation and development is continuing on the sonic drill by the Petro-Mechanics Research division, Borg-Warner Corporation, in North Hollywood, California.

No less impressive, and now in advanced stages of development, is a sonic oil well pump. Like the sonic drill, the sonic pump is a development of Albert G. Bodine, perhaps the foremost authority on the practical application of infra-sonic energy in the world.

This sonic pump, with its ramifications, may ultimately prove to be the biggest item of all in the application of sonics to the oil industry. Also to be strongly considered is the fact that field and laboratory tests have indicated that the sonic pump will inherently accomplish some secondary recovery.

The Sonic Pump

Unlike conventional oil well pumps, the sonic pump has no plunger, working barrel, sucker rods, or walking beam. The standard tubing string, however, is utilized for the sonic method of pumping (Fig. 1). This tubing string is supported by a small spring platform at the casinghead (Fig. 2), which gives the upper end of the tubing freedom of vertical movement, typically one-half inch strike. The lower end of the tubing string is merely suspended within the productive interval of the well.

Sonic Generator

A sonic generator, which also may be seen in Fig. 2, is mounted on top of the spring platform. This generator consists of two eccentric weights that rotate in opposite directions, in phase, so as to cancel their horizontal thrust, but joining cooperatively in vertical thrusts. Either an engine or an electric motor may act as prime mover to drive the wave generator in its function as a tubing oscillator.

A periodic up and down movement, typically 20 cycles per second, is thus applied to the top of the tubing, transmitting elastic wave energy down the well. The waves in the tubing travel with the speed of sound within the metal of the tubing (approximately 16,500 ft per sec), and the tubing is resonated at some standing wave overtone. Under these resonant conditions regions of the tubing (approximately every 400 ft) alternately elongate and contract in rapid succession, rather than the entire tubing string moving as a whole, with uncontrolled stroke. Consequently the elastic oscillations of the tubing are well within the safe elastic range of the tubing metal.

Low Pressures

These elastic oscillations propel the liquid stream upward by virtue of a series of one-way check valves that automatically open on the down-stroke and close on the up-stroke. The check valves are spaced one per joint of tubing and are sealed within the couplings of the made-up joints. Thus the valves oscillate with the tubing and on the up-stroke the closed valve acts as an impeller, and on the down-stroke, which is in excess of 1 g, the ball check is forced open and the pipe and valve move downward, allowing the impelled fluid to coast through until the next upward impulse. As the total amplitude approximates ½ in. at 20 cycles per second, it may be readily seen that a considerable amount of fluid will be lifted over a given period.

As each valve is subjected only to the weight of the oil in one length of tubing, it is required to handle only about 15 psi for standard lengths of 2½-in. tubing. Because of this low pressure, the valves are not subject to erosion, "torching," etc., as are high pressure valves, and therefore can handle sand and other abrasives, as indicated by tests to date.

†Editor, Pacific Coast.

*The Petroleum Engineer, October, 1954.

EXCLUSIVE

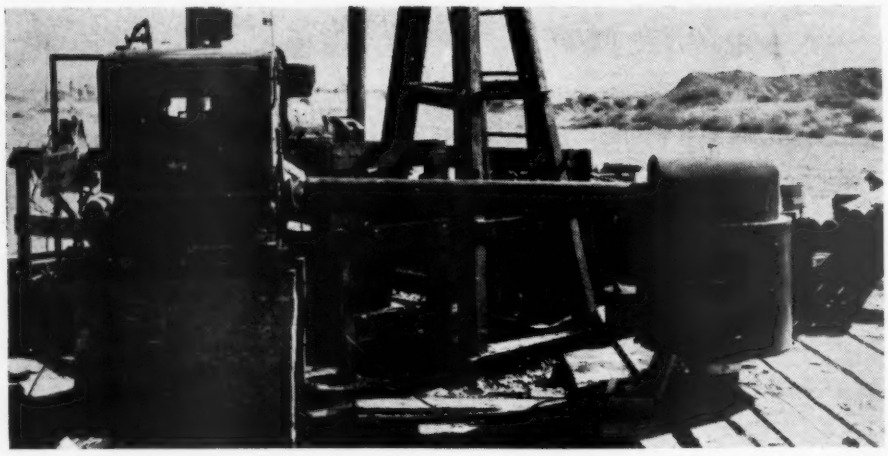

Fig. 4. Sonic pump installation powered by internal combustion engine.

Lateral Vibrations

If the tubing is not restricted in a horizontal plane, it will tend to vibrate laterally as in a violin string. This vibration does no useful work and therefore causes a large waste of power. More serious, it imposes bending load, particularly at discontinuities such as tubing joints, and causes tubing failures.

Analysis of tubing failures due to laterals has shown that the failures occur at the lower end of the tubing rather than just below the top where the loads are the highest due to the longitudinal waves. To assure the elimination of lateral vibrations, a system of spacer guides has been developed that hold the tubing concentric with the casing. These permit the necessary vertical freedom of the tubing, permit the free passage of gas through the casing annulus, and eliminate the power waste and tubing failures due to laterals.

Directional Wells

The guides consist of rubber spiders secured to the tubing with wide plastic rings. These rings provide the contact between the guides and the casing. During the initial stages of operation of the pump they deposit a light film on the wall of the casing. This slick film provides a bearing surface between the guides and the casing that practically eliminates friction and wear.

The use of these guides also permits the application of the sonic pump to crooked and directionally drilled wells. Field tests have shown that the sonic pump operates efficiently in crooked wells, while laboratory tests indicate that it will function at almost full efficiency in directional wells up to the horizontal.

Under some well conditions it has seemed desirable to lubricate the plastic guide surfaces by simply running a small trickle of production back down the annulus. In one recent instance tubing breakage occurred and it was discovered that oxygen was entering this lubricating fluid as a result of careless installation of surface equipment. The breakage, it was determined, was the result of oxygen fatigue and the problem was solved by simply eliminating the introduction of oxygen.

Tubing Stresses

Assuming the sonic vibrations in the tubing are purely longitudinal or vertical, the stresses in the tubing are the sum of the static stresses due to the weight of pipe and oil column and the alternating stresses due to the sound waves. Calculations show that the

FOR FAST FISHING TOOL RELEASE
WHEN YOU WANT IT
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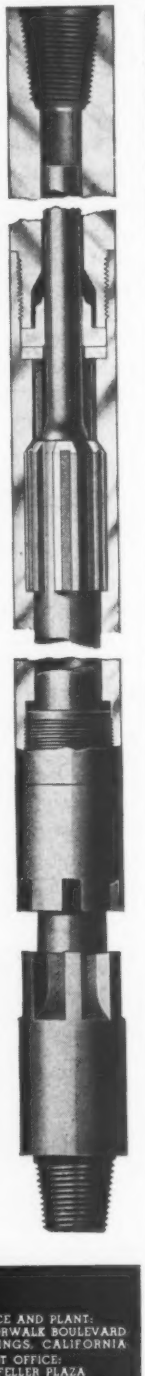

RELEASING type fishing tools such as spears, sockets, overshots and cutters require downward blows for release of slips or grapples . . . *and the handiest tool you can use to obtain downward blows when fishing with equipment of this type is the Bowen Bumper Sub.*

Operators not only find it a valuable tool for fishing jobs, but in addition use it above the bit or reamer when drilling in sticky formations. The Bumper Sub will jar down by simply dropping or springing the weight of the run-in string the full length of the stroke. Or —to free a bit or reamer—it is instantly ready to jar *up* by merely taking tension on the string and suddenly releasing it until the Sub is partly open. The rebound of the pipe causes the Sub to strike a hard upward blow. *Moreover, you can alternate upward and downward blows without making any adjustment in the tool from the surface!*

During regular drilling or fishing operations, the Bowen Bumper Sub is an integral part of the string. It easily withstands all the torsional strains of drilling and is packed off with a special abrasive and pressure resistant packing that permits high circulation pressures to be used without leakage. It is amply strong to stand the abuse of drilling and fishing under all conditions, and requires only occasional servicing.

You can use the Bowen Bumper Sub at any desired point in the drilling or fishing string. It is made for use with all standard sizes and types of drill pipe, and in special types which permit free passage of wire line tools, core barrels, etc. *Write Bowen direct for full details!*

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Fig. 5. Tubing centralizes and guides eliminate lateral vibrations but permit easy vertical motion.

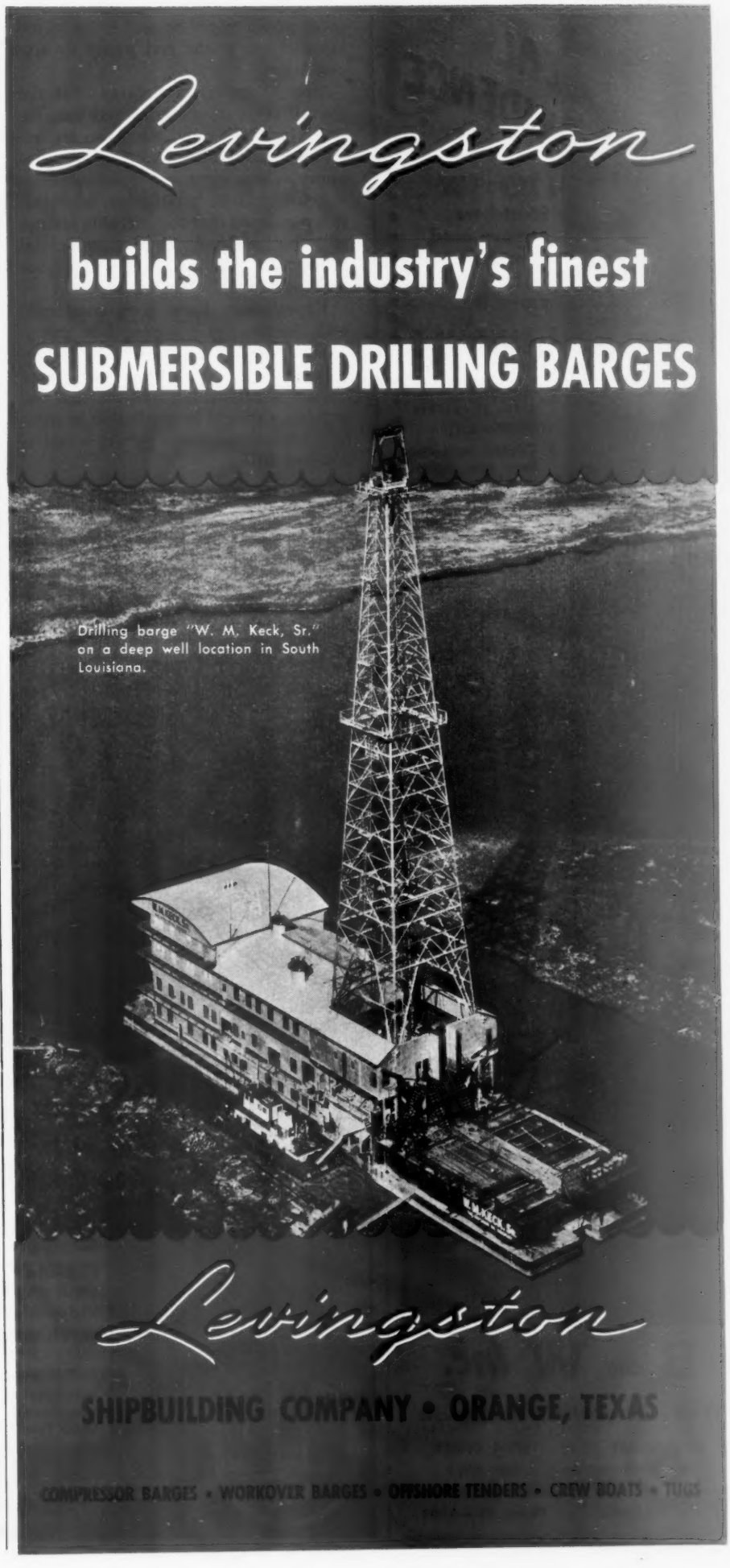
stresses in the top rod of a conventional oil well pump are in excess of 1½ times these values. Further, since the sonic pump is free from uncontrolled vibrations and shock, the above stresses remain constant.

The longest period of time that the sonic pump has operated continuously without tubing breakage was a period of approximately two years. Based on engineering principles, however, after the passage of five weeks a point has been reached where infinite life is indicated. This principle is applied the same as to other reciprocating machinery, and in practically all recent tests with the sonic pump, tubing life reached beyond this indicative period.

Although no tests have been made to date below 6100 ft, a quite recent development indicates that there are no practical limitations of the depths that may be pumped with sonic action. This new development employs the use of catcher anchors, which are firmly set on the casing at repeated intervals. Support springs that are mounted on the catchers are able to carry a large portion of the tubing. This method, which has been tested successfully, virtually eliminates depth limitations due to static stresses against the tubing.

Power Requirements

Power requirements cannot be calculated directly because of dampening, etc. Pumping efficiencies of 58 per cent have been obtained in a high water cut well at a rate of 430 bbl per day, using 2½-in. tubing. In this respect, the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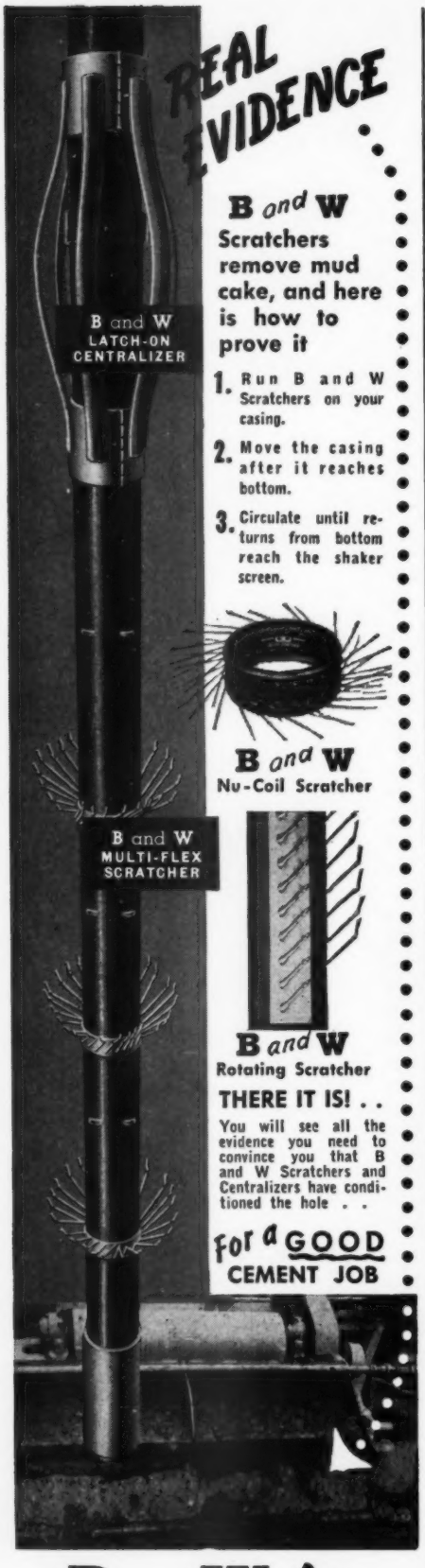
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sonic pump might be said to be in the same range as the rod pump in new condition.

Present experience shows that the overall costs of material and installation places the sonic pump on a comparable basis with the conventional rod pump. These costs are based on present, low volume production, however. It is presumed that considerable savings will be realized when commercial production and installation rates are reached.

Experiments have been conducted with the sonic pump using 1-in. macaroni as the production string. The results were as successful as with larger tubing, which would indicate that the technique should be applicable to slim-hole completion where tubing is run as a casing string.

Secondary Recovery

Conventional installations of the sonic pump in field tests have indicated that it will inherently accomplish some secondary recovery. Extensive laboratory tests have also demonstrated that earthen formations will deliver a considerably greater quantity of oil if a sound wave is transmitted through the formation. A method has been devised for augmented bleeding of vibratory energy from the bottom of tubing string to accomplish secondary recovery.

In summarizing the advantages that may result from the application of sonics to oil well pumping, the following appear to be of greatest interest:

(1) Expected low manufacturing and maintenance cost.
(2) Ability to pump sandy fluids and nonlubricating fluids such as water laden oil, without excessive wear or plugging.
(3) Ability to pump efficiently crooked or directionally drilled wells.
(4) Inherent high pumping rate.
(5) Low power requirement.
(6) Inherent ability to improve formation flow and facilitate secondary recovery.

Experimentation with the sonic pump was begun more than three years ago and progress has been both steady and gratifying. All field testing has been conducted with the cooperation of a major oil company and each successive test seems now to bring the sonic pump closer to its final development.

References

Vibration and Sound by T. M. Moore, professor of physics, Massachusetts Institute of Technology.

A Text Book of Sound by A. B. Wood, professor of physics, University of Manchester, England.

Elements of Acoustical Engineering by Harry F. Olson, director of RCA Laboratories, Princeton, New Jersey.

* * *

OVER 100 GPH FOR EACH POUND OF PUMP

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Kinetics: Measurement of rate of chemical reaction.

Acid Kinetics in Limestone Formations

C. E. Clason*

A number of years ago an article was published that showed reaction rates while acidizing in limestone formations. It was an effort to prove that wells did not have to remain closed in for long periods of time following treatment and indicated pumping rates for best accomplishment.

The contents were accepted and verified by others, in fact a book was published with similar data.

Much later, fracturing problems brought on speculation as to size of crevices made by hydraulic pressures and their extent. It was then realized that a crevice wide enough to take a sand propping agent allowed room for very little volume of fluid per unit of area. In fact a 1 mm. (.04 in.) crevice holds about 0.328 cc. per sq in., and this is a comparatively large one in terms of permeability and capacity for production.

A comparison was then made with the apparatus used in rate of reaction work done earlier with acid and it was found that from 18 to 25 times as much was used per sq in. The question then occurred: Would not a thinner layer of acid react faster? Perhaps the apparatus was authentic under the conditions of use but did this reflect or simulate action in the formation? The reason for verified results from work of others indicated that all used similar or the same type of apparatus.

The only feasible method of approach was to reduce the volume of acid per square inch by increasing the surface area. Although the extreme accuracy could be in doubt, it would certainly be closer to actual conditions than before.

This method was followed by using screened limestone particles that gave an average size from which the surface area could be computed. When packed in a bomb, the void space gave a ratio of fluid volume, when filled, to the area and could be used under pressure.

It was thus determined by the proper manipulation that acid reaction occurred in from 3 to 5 minutes instead of from 40 to 50 minutes as given by the old method.

Bringing reaction time down to this low period, even with some inaccuracy, means that other variations, such as solubility of formation above a certain point and density of limestones or dolomites, have less practical effect upon the mechanics of reaction vs. fluid movement.

It is possible that a growing suspicion has existed regarding the validity of the older work. It seems strange that with the thousands of wells acidized in the last 23 years, we are just beginning to learn what is happening in the formation. How do we get results when reaction is so fast?

Limestone or dolomite formations are definitely different from sandstone. It is rare to find a formation with a high enough acid solubility suitable for this process that does not have varied sizes of crevices throughout the matrix which act as flow channels for oil.

Permeability determinations on core samples are usually of no value with reference to actual production potential of a well as a small core is not representative of the entire producing section. Core samples showing less than 1 md have been taken from formations that had wells that tested several hundred barrels per day. The flow came from crevices extending a considerable distance and now and then these crevices were evident in the core samples. Treatments with acid after an initial pressure build-up took the acid under a vacuum at the surface and allowed maximum pumping rate for injection.

Therefore, acid treating may be considered as crevice enlargement rather than injection throughout a more uniformly porous and permeable structure similar to sandstone formations. Enlargement or unplugging of these crevices aids in oil flow from the matrix and then on into the well bore.

Statement by the Author

A new generation of engineers and chemists are now on hand to be interested in acidizing wells. Requests for information long out of print are often received. A review of some old literature can often be of interest historically but a complete bibliography must be investigated in order to follow the evolution of new knowledge and arrive at the latest correct information.

Old statements in the light of present knowledge can often be embarrassing to the author, but, who has a better right to rectify and acknowledge wrong conclusions, especially when no objections have been raised in the interim and others fell into the same trap.

Acid Action and Travel

An analysis of theoretical formation conditions based upon suitable calculations together with use of others made

	10 Crevices	100 Crevices	1000 Crevices	10,000 Crevices
0.00004 in. (0.001 mm) crevice. 0.0833 darcie[3]				
50 gal/min..	560 ft	176 ft	56 ft	18 ft
100 gal/min..	790 ft	254 ft	79 ft	25.4 ft
0.0004 in. (0.01 mm) crevice. 8.33 darcies				
	176 ft	56 ft	18 ft	5.6 ft
	254 ft	79 ft	25.4 ft	8.0 ft
0.004 in. (0.1 mm) crevice. 833 darcies				
	56 ft	18 ft	5.6 ft	0.8 ft
	79 ft	25.4 ft	8 ft	1.13 ft
0.04 in. (1 mm) crevice. 83,333 darcies				
	18 ft	5.6 ft	0.8 ft	0.56 ft
	25.4 ft	8 ft	1.13 ft	0.8 ft

*Chemical Services Coordinator, Halliburton Oil Well Cementing Company.

EXCLUSIVE

by Muskat[2] may throw light on this subject.

The table shows the possible radius of reaction or distance in feet traveled by the acid at 50 gal per min and 100 gal per min during a reaction time of 5 min in varied crevice sizes and numbers.

It can be seen that in all cases spent acid is shoved ahead into formations. Apparently overall it has not had a deleterious effect. The radius for active acid is small in the larger crevice sizes and with increasing numbers of these crevices.

From our past experience perhaps we can get some idea of the actual conditions encountered.

Muskat states that the K_2 or permeability of the main body of limestone can be from 1.25 md to 10 md. Assuming a well drilled with 10-md permeability and with a Darcy formula developed for hydrafrac calculations, using acid as the fluid, we will take a pumping rate of 50 gal per min for 10 ft of hole.

Then 50 gal $= 0.0275\ HK_2P$

$= 0.0275 \times 10 \times 0.01\ P$ (K_2 in darcies)

$P =$ 18,200 psi pressure for this rate of pumping.

In a 5000-ft well the net pump pressure required would be 15,870 psi. In 10,000 ft it would be 13,540 psi.

For 20 md the pump pressure is 6770 psi and 4440 psi, respectively. High pressures thus can indicate low permeability and small crevice conditions. These pressures are much higher than usually encountered.

When 1 crevice of 0.001 mm has a K of 0.0833 Darcies, or more than 8 times as much, it will be seen that such a well as the above would have quite small crevices if they were very numerous. One crevice of 0.001 mm should only require one-eighth as much pressure if open.

Notice that this is the smallest crevice in the accompanying table.

It then seems evident that after a cleanout shot, with which we assume all obstructions to normal permeability have been removed, if the well still requires and continues at high pressure, we are working with very small crevices. The acid travel must be at quite some distance before reaction ceases, provided the rate of pumping can be at fairly high speed. A pressure breakdown could indicate breaking through channels of larger size from which the mud had not been removed previously. In these cases the radius of reaction will be less but it does not have to be as far because the greatest results are obtained by unplugging these sizes.

Consider a well with 100 crevices of 0.001 mm in height and a K_2 of 10 md. This as it stands should be a good sized well if all crevices are open as the combined flowing capacity should be 100×0.0833 or 8.33 darcies. So the chances are that a small volume of acid or a cleanout shot should make a good well. If not, the number of crevices are actually less.

With 100 crevices the acid travels to 176 ft radius at 50 gal per min before reaction ceases. A 1000-gal treatment dissolves approximately 10 cu ft of limestone. In 20 minutes the crevice heights are increased 10 times or to 0.01 mm. According to Muskat, the theoretical increase in production could be 17 times as much. With 7000 gal of acid it could be 100 times as much if the formation potential for this production was present.

It is evident that crevices up to 0.1 mm and 1 mm do not enter into the picture as requiring enlargement to permit increased production. If they are present and production is small, they are plugged off. Extensive radius of travel is unnecessary to clear them up. The greatest increases in production are from this type of work. Excessive amounts of acid are not required.

A 325-mesh sieve has openings 0.044 mm in size. It is quite easy to mud off at ordinary pressure. A 0.01-mm crevice could be considered as about the smallest that would receive any mud during drilling to any great distance from the bore hole. With cleanout shots and acid penetration as shown, good wells should be produced even with very few crevices, provided the formation as a body has some permeability. If the latter is not true the main crevices of this size cannot make a large well. Connecting up with vugular conditions can add to the production capacity somewhat.

It would appear then that the greatest difficulty for increasing production lies with crevices around and below 0.01 mm in thickness. Successive enlargements with stage treatments are still valid until pressure drops are obtained. Increased volumes can be used if stages are progressively easier to inject.

With formations containing countless variations in crevice sizes it is easily possible for just one or perhaps more of the larger size to be present but lacking drainage connections to sufficient areas for much production. When treating with acid, the injection rate can be fast with insufficient resistance to force acid into smaller crevices and enlarge them.

This condition is often found when retreatments are tried to restore decreased production. Acid can be expended on crevice sizes that are already large enough to produce more than can be forwarded by the formation pressure and existing tributaries.

More Recent Developments

Successful results have now been obtained, especially in open hole wells, by first blocking off the larger crevices with thickened acid, which then allows a following amount of regular acid to penetrate the finer crevices. This establishes greater flow to the well bore by enlarging channels that have previously been bypassed by acid.

Avoidance of emulsion formation and prevention of Jamin Action seem more important in view of the amounts of spent acid forced ahead without chemical enlargement of crevices.

Ability of equipment to obtain high pressure is valuable in that hydraulic fracturing can be done where few or small crevices exist. With a low viscosity fluid such as acid the fracture should not be wide so that a pump that gives enough pressure will have enough volume as pressure decreases.

Theoretically a thickened acid can produce a wider crevice and also allow existing crevices to be entered by following thin acid. High viscosity acid will then then thin up or lose viscosity by time passage or reaction and so act as a temporary plug.

To sum up, it seems that fast reaction, as found, does not interfere or prevent increased production in the larger crevices. With smaller crevices, even a 5-min reaction rate allows considerable travel of acid and the greatest accomplishment is continued channel enlargement out to the reaction-travel limit.

At 25 gal per min, this limit is 127-ft radius in 100 crevices of the relatively large 0.001 mm size and nearly 40 ft for 1000 crevices. A well with 1000 crevices of this size would be a maximum producer. Fewer and smaller crevices extend the radius of travel, so it would seem that present equipment and methods are ample and sufficient for acid treating. We have only learned what was actually being done and that there is no apparent good reason for slower acting thin acid or exceptionally large equipment. * * *

Acknowledgement is made to George Mihram, inorganic section leader for his constructive ideas with respect to method and laboratory determinations.

[2]Flow of Homogeneous Fluids—1937.

[3]From $K = \frac{10^6\ w^2}{12}$ darcies, with w = crevice in mm.

$2,500,000 Deal Set in Rocky Mountains

Details of a multi-million dollar oil and gas exploration program affecting nearly 500,000 acres in Colorado, Utah, and New Mexico were announced in Dallas, Texas, by John A. McGuire, president of Three States Natural Gas Company, and Walter L. Rice, president of Reynolds Mining Corporation.

Under agreements concluded between the two organizations, Reynolds will commence the drilling of ten wildcat wells on eight major undeveloped Three States lease blocks in the Rocky Mountain area before November 1, 1955, and has the option to continue exploration and development on another twelve lease blocks in 1956 and 1957.

Believed to be the largest independent exploration deal concluded in the three-state area since the opening of production in the San Juan Basin, the agreement is primarily designed to exploit properties with natural gas potentials for inclusion in new pipelines developing in the region.

Three States is at present delivering gas from fields in the San Juan area of New Mexico and the Clear Creek field in Utah. Colorado with 101,000 acres scheduled for testing this year, and Utah with 194,000 acres to be explored by drilling in 1955 are both essential reserve supply areas for additional gas products bound for the California and Pacific Northwest markets.

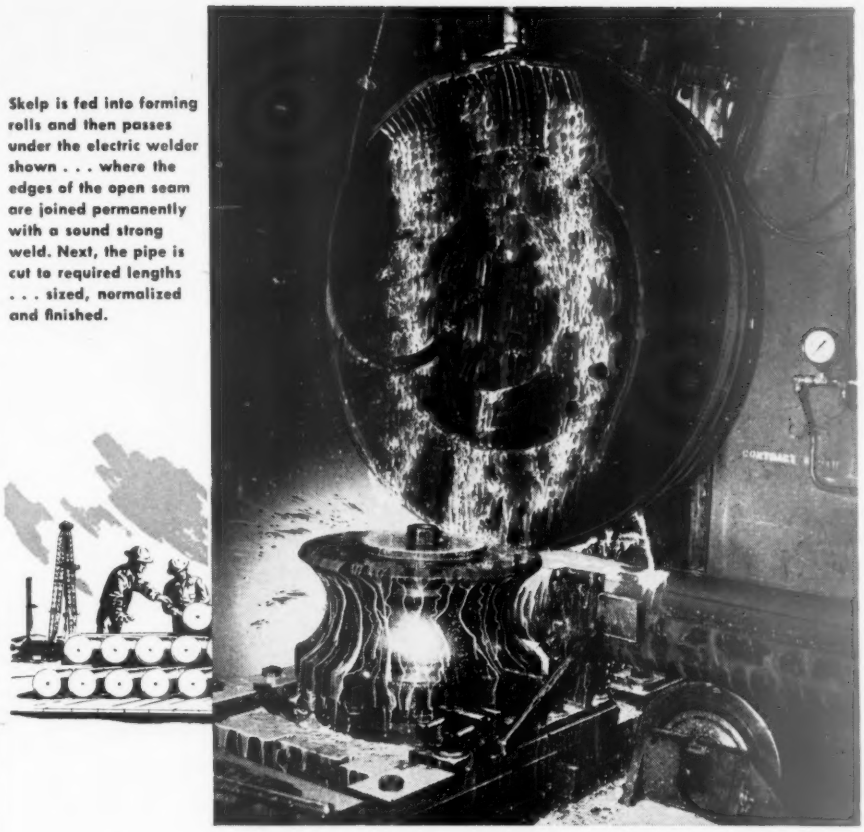
McGuire emphasized that only undeveloped properties are included in the Reynolds agreement, Three States retaining all of its present producing properties and continuing independent development thereon.

It is estimated that more than $2,500,000 was spent to acquire the properties committed to the Reynolds-Three States program.

Reynolds and Three States are jointly associated in the venture on a 50-50 basis, the former company earning its position by exploration and subsequent development and the latter company retaining its interest by virtue of lease-holdings.

The Three States agreement is the most extensive yet ventured by the Reynolds group.

In all, he said, Three States is contributing more than 350,000 acres to the joint venture. Other companies which will contribute approximately 150,000 acres, are Hancock-Utah, Ltd.; Western Natural Gas Company; San Jacinto Oil Company of Houston; J. H. Whitney and Company, New York; Albuquerque Associated of Albuquerque, New Mexico, and the estate of Paul B. English, of Farming, New Mexico, and Durango, Colorado.



Skelp is fed into forming rolls and then passes under the electric welder shown . . . where the edges of the open seam are joined permanently with a sound strong weld. Next, the pipe is cut to required lengths . . . sized, normalized and finished.

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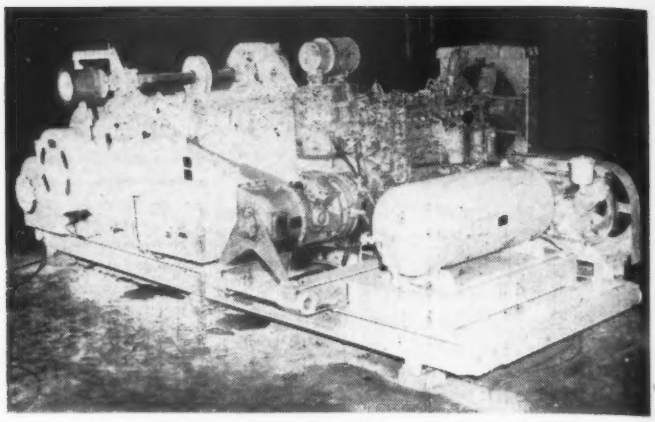
New rigs for VENEZUELA



Rigs are all powered by Cat D337 diesels. Transmission is through twin-disc torque converters and reverse gears.

A specially-designed portable drilling, workover and servicing unit is one of several recently completed by Ideco at Beaumont, Texas, for Creole Petroleum Corporation, Caracas, Venezuela, for use on Lake Maracaibo. The Ideco air-controlled rig is powered by a 233-intermittent hp Caterpillar D337 diesel oilfield power unit through a Twin-Disc torque converter, and reverse gear. Along with water pump, air compressors, generator set and control cabinet it is skid-mounted with an integral rig-house.

Catshaft assembly on the hoist includes a sandline guide sheave which rotates and travels freely on the catshaft. This assures proper line spooling inside the derrick.

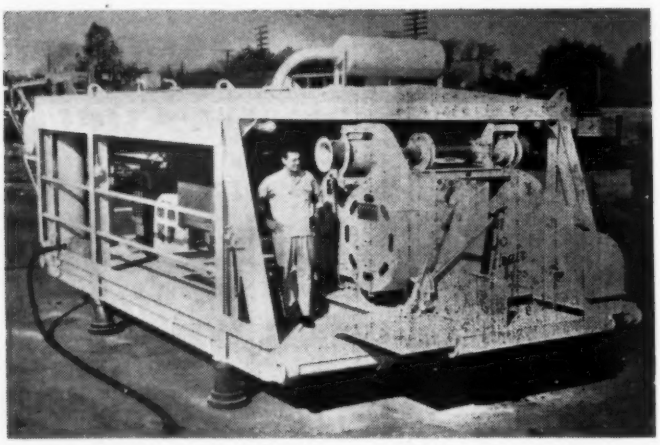
A Westinghouse 3YC air compressor is belt-driven from the hoist engine to power the air control system. A separate 5YC utility air compressor for powering air tools has an integral 15-hp electric motor.

The water pump is a two-stage Ingersoll-Rand model 1MRVN with a 7½-hp electric motor. Fifty feet of 1-in. wash-down hose is coiled conveniently on a spring-loaded reel.

The 20-kw generator set is powered by a Caterpillar D311 diesel engine. It delivers 60-cycle 220 or 440-volt alternating current. The sturdy skid-base and rig housing is 16 ft wide, 20 ft long, and has an overall height of 8 ft, 10 in. The roof is covered with 3/16-in. steel plate. Four lifting lugs permit the entire 27-ton unit to be lifted off the drilling platform by a crane.

Three of these units have been shipped from Beaumont and are enroute to Lake Maracaibo. * * *

Highly portable, all three rigs are mounted on 16 by 20-ft skids and housed by 8 ft-10 in. high structure.



West Texas Wildcat SETS Texas DRILLING RECORD

DRILLING depth records fell when a West Texas wildcat passed the 18,661-ft mark. A joint drilling venture of the Gulf Oil Corporation and the Hunt Oil Company, the well was a deep test of the Ellenburger formation, 35 miles southwest of Fort Stockton. It lies within the 100-mile Ellenburger drilling front extending from Andrews to Pecos counties which has produced many wells in the million-barrel class.

D. K. (Dewey) Davis, drilling superintendent for Penrod Drilling Company of Shreveport, Louisiana, contractors on the well, said coring operations started when the Ellenburger was topped at 18,395 ft. Despite the depth of the well, the remarkably little trouble and downtime encountered, plus good crew work, have bolstered the well's overall economy record.

Round trips from the bottom required nine hours with a drill string containing 21 6½-in. drill collars and weighing 350,000 lb.

The 1500-hp Brewster N-12 "golden rig" equipped with four General Motors twin-six diesels has eight hoisting speeds. From dual pump drives these engines furnish power to two Wilson-Snyder 20-in. mud pumps. Compounding clutches permit the driller to use any combination of engines to drive one or both pumps.

Other equipment on the rig includes a 22½-in. Brewster oil bath rotary table and heavy duty traveling block, and a Lee C. Moore jackknife mast. * * *

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"Red" can name many a cost-conscious driller who insists on U. S. Rainbow to help him drill *more* hole in the *same* number of days. In every oil field U. S. Rainbow V-Belts are hard at work, taking rough shock treatment on location after location, never letting anyone down.

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EXPLORATION ACTIVITIES

CALIFORNIA

★ Standard Oil Company of California is preparing to drill Hardison Ranch 2-2 near Fillmore in Ventura County. The wildcat location lies 2000 feet northwest of its Hardison Ranch 2-1 which was drilled to 15,630 ft; operations are now suspended. The well site, on Sec. 27-4n-20w, is a mile northwest of Standard's recent field discovery, Sespe Ranch 1.

★ Union Oil Company has announced the completion by its subsidiary, Los Nietos Company, of what appears to be a major California discovery. The company's wildcat, Bourdieu 55-1, southeast of the Guijarral Hills field in Fresno County, has been completed for initial flowing production of 2927 bbl per day of 30.2 deg clean oil. The discovery well was drilled to 10,737 ft and is producing from Gatchell sands cored from 10,592 ft to bottom. The initial flow rate was through a one inch casing bean, with 635 psi pressure and was accompanied by 3550 mcf of gas. Union has approximately 1600 acres of leases in this general area, which is located along the Coalinga Nose-Pleasant Valley-Guijarral Hills production trend.

★ Ferguson and Bosworth have made a new fault block discovery in the McDonald Anticline field in Kern County. The well, Honolulu-Layman 4 on Sec. 18-28s-20e was completed from the Point of Rocks sand, producing on the pump at the rate of 120 bbl per day of 42 deg oil.

★ Recovery of oil at a Superior Oil Company wildcat in the Northwest Belgian Anticline area near the town of McKittrick in Kern County indicated the possibility of a new discovery. Superior's well, Forbes No. 1, flowed 32 deg oil at a 42 bbl per day rate on a production test of the Third Point of Rocks sand between 4118-4126 ft. Gas production was at the rate of 107,000 cu ft daily.

This Israel-American Oil Corporation's rig stands on location of Rekmeh No. 1 in Israel. Gas was encountered in the area at a depth of 657 ft, indicating a new petroliferous region. This particular well is past 4300 ft, and may be projected to 7500 to 8500 ft.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Jan. 24	Jan. 31	Feb. 7	Feb. 14
Pacific Coast	147	145	140	141
Oklahoma	273	302	299	295
Kansas	157	180	170	168
Rocky Mountains	198	200	208	194
Canada	193	193	205	195
Ark-La-Tex	172	162	170	171
West Texas and New Mexico	473	482	495	501
Gulf Coast	535	525	529	519
Illinois	126	131	132	123
North Texas	300	310	322	323
Total	2574	2630	2670	2630

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

OREGON

★ First of three wildcats to be drilled by El Paso Natural Gas Company has been plugged and abandoned at 7470 ft. The well, designated the No. 1 Federal, in Malheur County, is in the Vale-Ontario area.

OKLAHOMA

★ A show in the Marmaton limestone is reported at United Producing and Cities Service jointly-owned Miles "B" No. 1 test in Beaver County.

On drillstem test in the lower Marmaton betweeen 6077 and 6089 ft, 80 ft of free oil was recovered, together with 90 ft of oil and gas cut mud and 10 ft of mud cut oil. The oil was 41.5 deg and the flowing pressure was 25 to 27 lb. The 20-minute shut-in pressure was 1275 lb.

This well is on a 640-acre unit owned half by Cities Service and half by United Producing. Nearest Marmaton production is 20 miles away in the South Flores pool.

PERU

★ Douglas Oil Company of California is drilling ahead in a deep test in the Lobitos area of Peru. It is being directionally drilled from a beach location, will bottom about 600 ft from a discovery well drilled by Compania Petrolera Lobitos. The discovery well is presently producing 450 barrels a day of 40 gravity oil through a 14/64-in. choke.

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Exploration

CANADA

★ Union Oil Company reported a new gas discovery in British Columbia, about 60 miles north of Ft. St. John and 16 miles west of the British Columbia-Alberta border. On a drillstem test of the Triassic interval, from 3417 to 3437 ft the wildcat well tested at a rate of approximately 5000 mcf of gas per day. The nearest production is about 35 miles to the southwest. The discovery well, Milligan 1, is jointly owned by Union Oil, Hudson's Bay Oil and Gas Company, and the British American Oil Company, on a 255,000 acre provincial reservation.

TEXAS

★ Cities Service Oil Company's wildcat in the southeast corner of Henderson County has opened up a promising new area in the James lime. No. 1-E Hugh and B. White flowed on drillstem test at 10,052-67 ft, drawing attention by a near blowout while coring that zone. Company has set casing, and indications are for a good gas-condensate producer.

★ Gulf Oil Corporation and Hunt Oil Company et al No. 47 Elsinore Royalty, established as Texas' deepest wildcat, was declared a failure at total depth of 18,763 ft in the Ellenburger. Well has been plugged back to a possible productive zone between 3800-3900 ft. The test, located 35 miles southwest of Fort Stockton, in Pecos County, revealed only water and jellied mud on drillstem test in the Ellenburger, topped at 18,395 ft.

★ First Ellenburger discovery in the Panhandle has been chalked up by Phillips Petroleum Company's Troy A. No. 1, located 16 miles east of Pampa. Production came from 11,370 ft, with a flow of 60 bbl of 44 deg oil in an hour and a half drillstem test.

NEVADA

★ Elbert and Nepple have suspended operations on a wildcat on the Bruffey Ranch in Eureka County. The well was drilled on sec. 3-27n-52e and was suspended at a depth of 4909 ft.

ARIZONA

★ Colorado Basin Associates, Inc., has suspended operation on Federal 1, a wildcat located 12 miles southwest of Yuma. The well was drilled on sec. 24-10s-24w and was bottomed at 6012 ft.

KANSAS

★ Pyle field has been opened by Gulf Oil and Falcon-Seaboard Drilling Company's wildcat in Kiowa County. The No. 1 Pyle flowed 304 bbl daily from the Mississippian at 4666-80 ft.

Leasing, Taxation Course Offered

Thought to be the first of its type ever offered, the University College and the Department of Business Administration of the School of Commerce of the University of Southern California is currently conducting a 15-week evening course in petroleum leasing and taxation.

Beginning January 12, the course has been meeting every Wednesday on the USC campus. The course is designed for businessmen interested in the leasing and taxation problems of the oil industry.

The content of the course includes highlights of habendum, drilling, rental, surrender and forfeiture clauses of oil and gas leases; express and implied convenants; assignments and transfers of oil and gas leases and interests therein; payment, transfer, and apportionment of rents and royalties; basic petroleum law; and a summary of petroleum taxation problems, including intangible deductions, oil depletion, and transfers of oil interests.

Instructors for the course are Earl Hightower and John L. Martin, of Hightower and Martin, law firm of Los Angeles.

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Texas oil is Texas progress. The Victoria Bank & Trust Company is proud of its contribution to Texas progress through oil financing. Our aim in the future is to render ever increasing service to oil men through the medium of our Oil & Gas Department, which has been established to render specialized aid to the industry. Bring your development and producing problems to us. We speak your language.
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Safety Campaign Wins $54,000 Insurance Rebate

A safety campaign among employees of Thomas P. Pike Drilling Company, Los Angeles, which reduced the accident ratio by 50 per cent, has won the firm a $54,000 rebate of insurance premiums paid out during 1954. Of this amount, 30 per cent, or $16,200 goes to the employees in accordance with the system of incentive management with profit sharing under which the firm operates.

Oil well drilling is rated a dangerous occupation by insurance companies and consequently the insurance rates for workmen's compensation are relatively high. In an effort to make the business safer for employees, Pike started a safety campaign on April 1, 1953, under the direction of Ben West, safety director for the firm. A scientific analysis of all accidents over a long period was made, and the results were tabulated to determine the causes in general of all company accidents, and those of each particular class.

Armed with this information, West held meetings with the company's drilling-rig foremen and the drillers in which the accident data was studied and rules formulated for future safety measures. The foremen were also asked to point out the effect of accidents on the profit sharing fund.

The results were immediate and impressive. The accident rate fell 30 per cent in the first three months and leveled off at an average reduction of 50 per cent for the campaign year. This lower rate has been consistently maintained ever since, and promises to earn further dividends from the insurance carriers on the same basis as the current award.

Under the plan of incentive management with profit sharing, every employee not only shares in the profits but has a voice in the management as well. If compensation insurance rates are high, the profit is less; if they can be reduced, as in this campaign, there is a net gain for the firm's profits.

Moving to a New Address?

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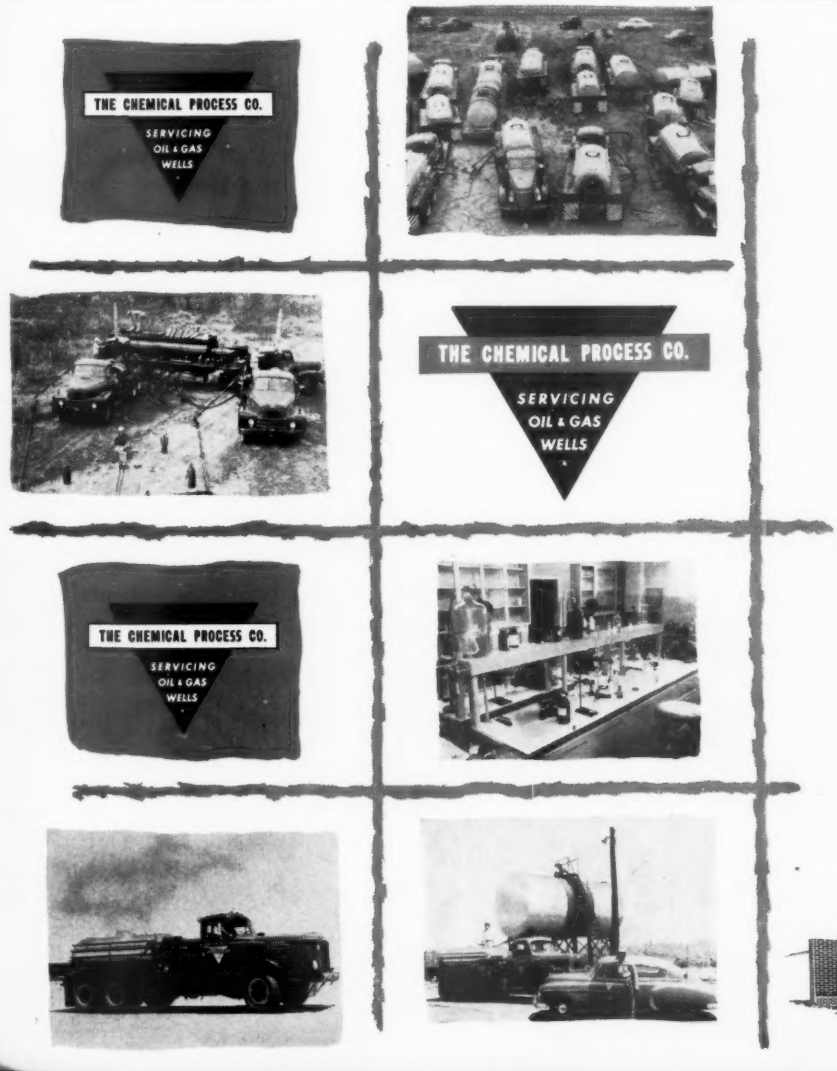
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The Chemical Process Co. is one of the oldest well service outfits in the oil patch. We were the first servicing company to acidize a well in Texas, Louisiana, and Oklahoma. Our first well was treated 23 years ago. We originated the chemical treatment of wells as it is known today. Every modern facility for treating oil and gas wells is available to our customers; we operate more than 400 pieces of field equipment, 25 short wave radio stations, more than 100 mobile communication units, 28 branch offices, and the combined oil field experience of our personnel is more than 2,000 years. We maintain our own research laboratory for the water, brine, core, cuttings, and other field analyses of our customers. We have a record of experience and achievement that is unexcelled in the well service field.

The facilities of this modern, efficient organization, and the services of its field technicians, are easily at your disposal. If you are not a Chemical Process Company customer — you should be. Because then the best outfit you can have will be working on your well. The Chemical Process Company, General Offices and Laboratory in Breckenridge, Texas. Stations Throughout the Mid-Continent Area.

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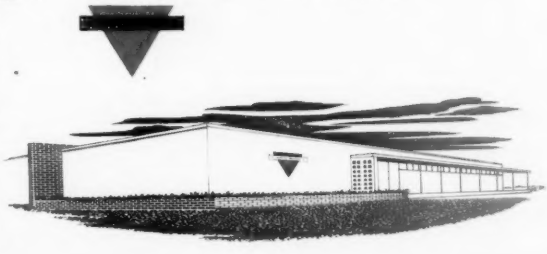


WHAT'S DOING IN DRILLING

OKLAHOMA

★ In Grady County, Magnolia Petroleum Company has expanded the new Southeast Bradley field with its No. 1 Thomas Estate. This well flowed 336 bbl of 39 deg oil on a 24-hour test through 16/64-in. choke from perforations at 8964-9042 ft. Gas oil ratio was 518:1. Total depth was 10,500 ft, with casing set to bottom. Well was plugged back to 9086 ft prior to the successful test.

★ Heavy producers by the dozens are still being finaled in the Osage Mineral Reservation, Osage County. Most significant of late are Oras A. Shaw's No. 9 and 10. Through a ¾-in. choke, the No. 9 Osage bottomed at 2989 ft, flowed 109 bbl per hr on initial test. The No. 10 flowed 101 bbl per hr on a similar choke. Total depth on this one was 2993 ft. Triangle Oil No. 7 bottomed at 1964 ft, did 6 bbl an hour through a $\frac{1}{16}$-in. choke.

KANSAS

★ National Oil and Gas and Republic Natural Gas No. 1 Young has been completed with a potential of 3000 bbl calculated daily. Flow came from perforations at 4196-210 ft in the Chero sand. Casing was set at 4484 ft; total depth was 4488 ft. Well is in SW NW NW of 15-19n-20w in Rush County.

CALIFORNIA

★ Discovery of a new zone in the area of the Exeter pool about 2½ miles southeast of the city of Taft in the Midway-Sunset field, Kern County, was confirmed by Exeter Oil Company. On a test of an interval between 3953-3988 ft in Exeter's 14J well, 30 deg clean oil flowed at a rate estimated in excess of 500 bbl per day.

★ Union Oil Company has completed Whittemore 5-26 in the North Guijarral Hills field, discovery by Union in 1954, for initial flowing production of 740 bbl of 39.8 deg oil. Flow is through a 24/64-in. choke, with 630 psi tubing pressure. Production is from Leda Sands at a depth of 8860 ft.

★ Union Oil Company completed Bell 24-26 in the North North Guijarral Hills field for 782 bbl per day of 40 deg crude from a total depth of 9020 ft.

★ Union Oil Company completed Kernco 31-34 in the Rio Bravo field for 359 bbl per day of 35.8 deg crude from the Helbling sands at a depth of 11,696 ft. Stearns 142 added 340 barrels of 24.7 deg crude while Sansinena 8B-14 was completed for 337 bbl per day of 27.7 deg crude and Sansinena 11 B-2 for 219 bbl per day of 27.5 deg crude.

This wildcat well on the Linns W. Worth farm in Harper County, Kansas, belongs to the Musgrove Petroleum Corporation, with the Co-operative Refinery Association of Kansas City. Musgrove drilled the 5000-ft well in 25 days including moving in and out. The rig is a Caterpillar-powered Emsco.

TEXAS

★ Forest and Cities Service have completed the biggest oil well to date in the War-San field of Midland County. Their Dora Roberts C-4 No. 3, finaled for a flowing potential of 3486 bbl of oil daily, based on a flow of 581 barrels of 52.5-gravity oil in four hours. Tubing pressure was 675 pounds and the gas-oil ratio was 742/1.

Top of the Ellenburger was logged at 13,020 feet and the well flowed from open hole between 13,020 and total depth, 13,125 feet. This is the fourth completion by Forest Cities Service in the War-San field.

★ Harrell and Southworth added its No. 1 Walter C. Scharbauer to the many successful Spindletop Dome wells in Jefferson County. The new pay zone gave up 100 bbl per day through a 9/64-in. choke through perforations at 5419-23 ft. Gas-oil ratio was 160 to 1.

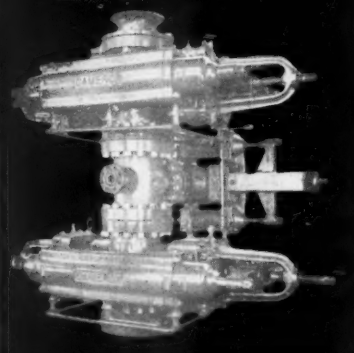
★ In Limestone County, a Smackover lime discovery on the southwest side of the old Mexia Woodbine field was registered by Humble Oil Company. Its No. 1 Joe Ross Heirs, bottomed at 8614 ft, found the lime at 8565 ft. Flow on initial potential test was high, but since has been falling off rapidly.

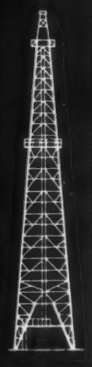
Summary of drilling activity for January.
(As compiled by Rinehart Oil News Staff)

States	New locations		Wildcat completions			Field completions			Junked & abnd.		Temp. abandoned		Abandoned locations		Current active wells	
	Wc	Field	Oil	Gas	Dry	Oil	Gas	Dry	Wc	Field	Wc	Field	Wc	Field	Wc	Field
Alabama	4	1	0	0	6	1	0	0	0	0	0	0	0	0	9	1
Arizona	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Arkansas	12	35	1	0	7	22	1	6	0	0	0	0	0	0	13	26
Canada (Williston B.)	14	47	0	0	7	14	0	3	0	0	0	0	1	6	15	27
Colorado	50	39	7	4	57	23	2	21	0	0	0	0	2	1	56	43
Florida	5	0	0	0	4	0	0	1	0	0	0	0	0	0	2	0
Georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kansas	77	260	9	3	62	137	26	67	0	0	0	0	1	2	53	292
Louisiana	36	274	0	1	32	212	43	53	1	1	0	4	2	7	64	217
North	11	136	0	1	10	131	19	24	0	0	0	1	0	4	13	43
South	25	138	0	0	22	81	24	29	1	1	0	3	2	3	51	174
Mississippi	13	26	0	0	12	8	1	5	2	0	0	0	0	0	20	22
Montana	2	17	1	0	7	10	1	8	0	0	0	1	1	0	28	30
East	1	5	1	0	1	3	0	1	0	0	0	1	0	0	8	13
West	1	12	0	0	6	7	1	7	0	0	0	0	1	0	20	17
North Dakota	2	6	0	0	3	10	0	0	0	0	0	0	0	1	5	19
Nebraska	22	37	2	0	25	13	0	6	0	0	0	0	0	0	13	35
Nevada	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	1
New Mexico	22	67	3	1	10	53	31	7	0	0	1	1	0	2	41	132
Eastern	18	53	3	0	7	53	4	5	0	0	0	1	0	2	36	101
San Juan	4	14	0	1	3	0	27	2	0	0	1	0	0	0	5	31
Oklahoma	47	481	8	2	57	315	25	102	0	0	1	0	1	10	66	511
South Dakota	3	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0
Texas	440	1299	77	19	355	765	67	193	1	1	11	8	18	55	426	885
East	20	41	1	0	31	33	7	18	0	0	0	1	3	3	23	54
Gulf Coast	35	98	2	5	32	63	8	23	0	0	0	0	0	0	40	96
North Texas	91	277	20	1	58	140	8	39	0	0	0	0	0	7	77	114
Panhandle	8	86	0	0	2	34	19	5	0	0	0	0	0	4	19	34*
South Texas	97	248	8	9	60	138	19	33	0	0	4	5	0	4	62	105
Border Co.	27	46	7	1	31	73	0	8	0	0	2	0	1	5	25	60
West Central	109	162	33	2	103	108	4	53	0	0	1	0	8	8	48	54
West Texas	53	341	6	1	38	176	2	14	1	1	4	2	6	24	132	368
Utah	4	1	0	0	4	2	0	1	0	0	1	0	0	0	19	3
Wyoming	12	46	0	1	23	33	0	6	0	0	0	0	0	1	40	72
Totals	370	2636	108	31	673	1618	197	479	4	2	14	14	26	85	878	2316

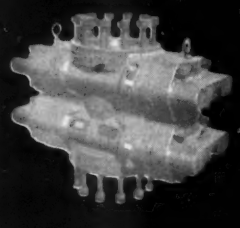
* Figure incomplete.

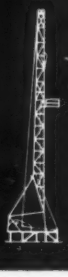
● QRC Preventers and HCR Flowline Valves for high substructure rigs.





● SS Preventers for portable type rigs having low substructures.





Blowouts still happen . . . as witnessed above . . . even on the best regulated rigs, but Cameron Drilling Control Equipment, in the hands of safety-conscious operators, has gone a long way toward eliminating blowouts. As drilling depths have increased, so have well pressures, and the need for more dependable pressure control equipment. Constant research and improvement in this field has enabled Cameron not only to keep abreast but to keep ahead of the industry's needs.

Cameron

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Drilling

CANADA

★ Canadian Bishop Oil, Ltd., has completed its Pembina 8-4 well to production on a 320-acre lease in the Pembina Oil field of Alberta Province and the well flowed at the rate of 300 bbl daily through a ⅛-in. choke on 12-hour test. It is producing from the Cardium sand at approximately 5082 ft.

★ Union Oil Company and Hudson's Bay Oil and Gas Company have reported completion of two new extension wells, about two miles southwest of the discovery well in the South Sturgeon Lake Field, Alberta, Canada. One well came in flowing at a rate of 1450 bbl per day of clean oil from a depth of 8331 ft. The discovery well was completed flowing at a rate of 4500 bbl per day, while the second well 4½ miles to the west, had an initial flow rate of 1200 bbl per day.

★ British American Oil Company has completed its first well in the Pembina field. Pembina 12-36 flowed 15 bbl hourly through 10/64-in. choke. Open flow test showed 40 bbl hourly.

PENNSYLVANIA

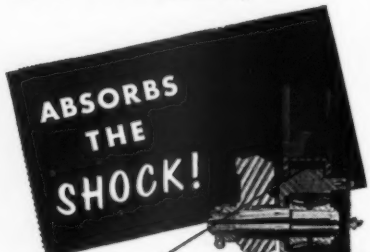
★ New York State Natural Gas Company has finished up a new 60,000,000 cu ft gasser in the Leidy field, bottomed at 6740 ft. Original well in the Leidy area has been abandoned, although the original gas potential well was rated at 100,000,000 cu ft. This well was completed in 1950.

KENTUCKY

★ Stouder Drilling Company No. 1 Freeman Tucker, in Union County, flowed 248 bbl daily from the McClosky lime at 2714-19 ft. The well is a McClosky step-out and is one-half mile from Aux Vases sand wells.

JENSEN'S

Wrist Pin Assembly



Further proof of JENSEN'S superior construction. The bearing housings of the wrist pin assembly are cleverly designed with a heavy compression type rubber strip located above and below the bearing to absorb the shock and vibration from the well load. Stroke length changes are made easily and quickly. Wrist pins are cut from alloy steel and taper fitted to the crank.

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Rotary — Percussion-Drill Demonstrated

IN Simi Valley, southern Ventura County, California, an interesting drilling tool has been under development for many months. Designed to combine some of the advantages of hard-rock drilling found in the cable-tool method with those inherent to rotary drilling, the device is being developed by the American Percussion Tool Company and was recently shown to the industry.

The demonstration was conducted in three phases in order to afford comparative results between rotary method as compared to rotary-percussion action. The gross tool string load amounted to 8500 pounds. Conventional 12¾-in. tri-cone bit was installed on the new tool. A granite boulder having the hardness of 6.6 was embedded in the surface of the earth under the drill rig.

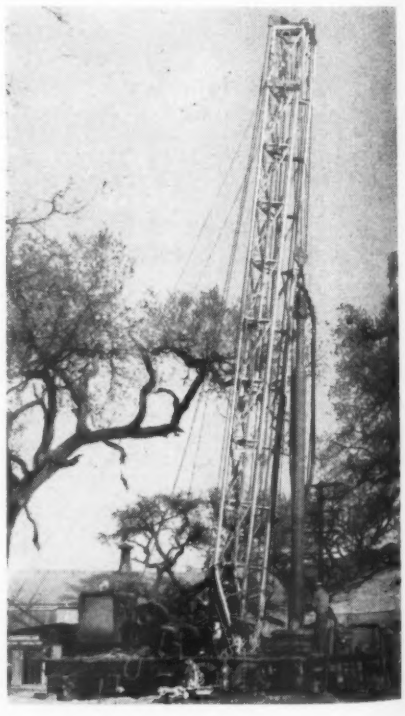
The first test, using straight rotary action, was limited to 10 minutes. A table speed of 100 rpm was used as faster operation was not practical because of the irregular hole bottom pattern. Mud circulation was used to remove cuttings. At the end of this ten-minute run the hole progressed amounted to 5½ inches.

The second test was made with rotary-percussion action and at the same speed and time interval as in the first run. At the conclusion of this run the progress was found to amount to 11 inches.

Since the action of the bit when using rotary-percussion leaves a cleaner, smoother bottom hole, it is possible to run at much higher table speed, affording faster hole progression. Hence, it was decided to demonstrate the rotary-percussion at a more suitable table speed of 175 rpm, using the same bit, same running time of 10 minutes. This time the tool made 19½ inches.

It was quite noticeable that the straight rotary action had left an irregular hole bottom which was being progressively aggrevated with continued running. Upon starting the test with percussion action added it was very evident this action was rapidly resulting in smoothing out the hole bottom. After this was accomplished the rate of penetration increased appreciably.

The differential of drilling rates between rotary and rotary-percussion amounted to 3.3:1 ratio. Undoubtedly this differential would have been even greater had the tower height permitted the use of an additional drill collar bringing the loading nearer the desired 30,000 lb rather than the 8500 lb used. Also it should be brought out that the granite boulder was "floating" due to the soft supporting earth because of recent heavy rains. It is theorized that a good amount of the percussion action was absorbed by this condition.



ILLINOIS

★ A large producer in Saline County has been reported. Barton and Associates' No. 1 Lucile Goschorn Unit flowed 1560 bbl daily through a ¼-in. choke from the Tar Springs at 2184-200 ft.

KANSAS

★ Activity in Kansas was filled with light producers spotted over the state. In Pawnee County, C. U. Bay's No. 1 Carpenter A, was completed as a nice producer from the Pennsylvanian and Mississippian contact point at 4208-16 ft. Although official state potential has not been made, permit to produce the well at 25 bbl daily has been allowed.

★ No. 1 Strobel, owned by J. J. Lynn and Sterling Drilling Company, has been completed as a good producer from the basal Pennsylvanian. Potential was 39 bbl daily, flowing from perforations at 4310-15 ft and 4320-23 ft. The well is located west of Garfield, Pawnee County.

NEBRASKA

★ In Cheyenne County, Ryan-Davis Oil and Cimarron Western Drilling Company, has completed its No. 1 Graham. Well pumped 168 bbl from the J sand perforated at 5217-5223 ft, and is located some distance from other producers in the Woten pool.

Annual Index

for

1954

The

Petroleum Engineer

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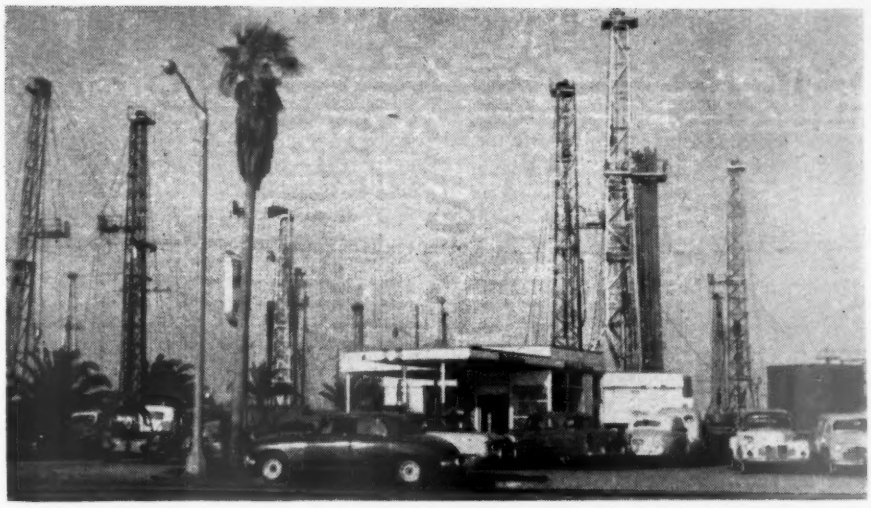

Twelve rigs are visible from this one vantage point in the Huntington Beach area. Initial excitement has died and operators are watching cautiously as pressures drop and production declines.

OIL BOOM,

CALIFORNIA STYLE

The Huntington Beach drilling boom has now reached the stage of a full scale Hollywood production. It all started with the New Year's Day discovery by a 24-year-old geologist named Jack Crawford when he brought in Huntington No. 5 on a townlot, at the corner of First and Walnut streets in this sleepy little beach community.

Rated as a new zone discovery for this area, in the Jones sand, the frenzied drilling boom has already produced a total of about 20 wells within the Huntington Beach city limits. The new field lies inside the boundaries of an unrestricted drilling area that was laid out before the State of California set a restriction of one well per acre, so there is no limit to the number of wells that can be drilled.

At present there are about two dozen rigs active within a radius of a few city blocks with an additional 44 permits to drill granted. Royalties as high as 30 per cent are being offered to small land owners and bonuses as high as $25,000 are being paid, particularly to home owners where the location may require moving or destroying a home. More often than not the decision is made to destroy the home for the sake of expediency.

The wells are relatively shallow, averaging between 3700 to 3900 ft, so the equipment is small allowing drilling on lots as narrow as 25 ft. It is not uncommon for a homeowner to have a drilling rig operating in his back yard, a tank battery in his front yard and a pumping unit growling at his bedroom window.

Practically all of the operators are small independents and most of the landowners are old-time residents. At least for the present, many of them are reaping profits they had only dreamed of, and to others such wealth had not even acquired the status of a dream.

One ominous note is the fact that the decline curve appears to be swinging rapidly. Many of the wells that came in flowing are now on the pump. Where the early wells were coming in for initial production rates of from 600 to 1000 bbl per day, present wells are now completing in the vicinity of 300 to 500 bbl per day.

Preliminary results of a study by an engineering committee appointed by a pool operators committee, functioning under the Conservation Committee of California Oil Producers, indicated the Jones pool contains about 1100 bbl per acre-foot, or 180,000 bbl per acre of oil originally in place. While completed data on this pool has not been received from some of the operators, the committee estimates this type of pool should probably recover about 40,000 bbl per acre of the original oil in place.

In the final analysis, any operating profits that are realized out of this weird extravaganza may ultimately end up going only to those who got there "fustest with the mostest."

RUNNING TOUR with MEN in the INDUSTRY

D. C. Wellman

McKnight Enterprises, of St. Paul, Minnesota, has announced the appointment of **Dean C. Wellman** as Rocky Mountain area manager of its newly organized Arrowhead Exploration Company, which recently opened its offices in Denver, Colorado. According to Wellman the new company will concentrate on oil and gas exploration in the Denver Basin and the Rockies, at least for the present, but may branch out into other kinds of mineral exploration including uranium.

George D. McClelland has joined the staff of George Armistead and Company in Washington, D.C., as mechanical engineer. McClelland, Texas A&M graduate, had previously been employed by Magnolia Petroleum Company and the Hunt Oil Company. In the Armistead organization, he will be in charge of the mechanical engineering activities of the firm with headquarters in Washington.

Gerald F. Bassler has been appointed director of training for Continental Oil Company's manufacturing department, with headquarters in Houston, Texas. He succeeded **M. L. Cobb,** who recently was promoted to superintendent of Conoco's refinery at Ponca City, Oklahoma. Bassler has been management development supervisor for The Murray Corporation and previously had served five years as senior training supervisor for Creole Petroleum Corporation in Venezuela, South America, and two years with the training department of Detroit Edison Company.

Thomas P. Simpson has been elected vice president and director of manufacturing by the General Petroleum Corporation. Simpson succeeded **Gale L. Adams,** who retired. Simpson was formerly assistant director of manufacturing.

Western division, Searboard Oil Company, has announced the following changes in the California area: **E. R. Smith,** district production superintendent, Los Angeles, is being transferred to the Mid-Continent division, Dallas, as reservoir engineer; **L. A. Hamann,** district petroleum engineer at Kerman, will be transferred to Los Angeles to assume the position of district production superintendent.

J. P. Malott, Houston, Texas, has been promoted to manager of Continental Oil Company's production department. He was formerly assistant manager of production. **M. H. Dubrow,** Houston, chief petroleum engineer, has been promoted to the newly created position of chief engineer, production department.

John E. Blixt, former senior geologist for the Texas Company's Rocky Mountain area, has joined the firm of Halbert and Jennings in Denver, Colorado, and will be associated with the company in both exploration and development of oil and uranium. For the last four years he had been Texas Company's senior geologist in Denver, a position he resigned January 31.

Two additions to the company's technical staff have been announced by Gulf Coast Leaseholds, Inc. **W. P. Williams,** a petroleum engineer, and **Ray J. Thompson, Jr.,** a geologist, have joined the firm. Williams, a Texas A & M graduate, was resident manager of operations in El Mene, Venezuela, for the Falcon Petroleum Corporation. Thompson was geologist with American Republics Corporation in Houston. He is a graduate of the University of Houston.

M. C. Welch has been appointed to serve as assistant district superintendent for Sunray Oil Corporation's field operations in California. This new post has been created to better coordinate and direct the activities of the producing, drilling, gas and gasoline, and mechanical sections of the production department. Welch is a veteran of 25 years with Sunray.

J. W. Mays

W. L. Craig

Evans Production Corporation, Dallas, Texas, has opened a district office in the Fair Petroleum Building, Tyler, Texas, with **William L. Craig** as district manager. Craig is a graduate of Louisiana State University and prior to joining Evans was associated with DeGolyer and MacNaughton.

James W. Mays will serve the new office as district landman. He is a graduate of the University of Texas Law School. Mays was employed by the California Company as landman in Mississippi and Alabama and also engaged in the lease brokering business prior to joining Evans in April, 1954.

L. S. Osborne, assistant to vice president for oil development for Union Pacific Railroad Company, has been appointed assistant vice president for oil development.

R. E. McAdams, formerly manager of exploration for Shell Oil Company's Denver, Colorado, area, has been appointed manager of the firm's exploration department and transferred to Shell's New York head office. McAdams, a graduate of Texas A. & M. College, has been a member of the department he now heads for nearly 20 years. He joined Shell as a geologist in the Texas-Gulf area in 1936.

Retirement of **Alan J. Lowrey** of San Francisco, California, as vice president of Union Oil Company has been announced. Lowrey will remain as a director of Union Oil with which he has been associated since 1939, when he became assistant to the president with headquarters in San Francisco.

George A. Wilson, oil and gas executive, has been elected president of The TXL Oil Corporation. Wilson was president of Interstate Oil Pipe Line Company and the Yellowstone Pipe Line Company, affiliates of Standard Oil Company (New Jersey), both of which posts he resigned to accept this new office.

The firm also announced the election of **Maurice Newton,** partner, Hallgarten & Company and Maurice Meyer, Jr., partner, Hirsch & Company, as directors. Newton is also a director of Anaconda Copper Mining Company, Paramount Pictures, Inc., and other companies. Meyer is a director of Sorg Paper Company, Daitch Crystal Dairies Company, and other organizations.

Wilson succeeded **Col. George C. Fraser,** trustee and secretary of the Texas Pacific Land Trust, who had served as interim president since the formation of the new oil corporation.

H. P. Rogers

M. G. Rowe

Rowan Drilling Company, Inc., and Rowan Oil Company have both elected new presidents. **M. G. Rowe** was elected president of Rowan Drilling Company, Inc. **C. L. Rowan,** who had been president, became chairman of the board, and **A. H. Rowan,** who had been chairman of the board, remained as a director of the company.

Hamilton P. Rogers was elected president of the Rowan Oil Company. He was a practicing lawyer from 1938 to 1941, and became associated with Rowan September 15, 1941, as a landman. He later became head of the land department, assistant secretary, and then vice president, before being elected president.

Jack Sembower, manager of public relations, Pacific Coast area, for Shell Oil Company, has moved his headquarters to Los Angeles, California.

James A. Ransford has been appointed export manager of Tide Water Associated Oil Company's western division. Ransford has been with Tide Water since 1927.

Robert C. Hadden has been appointed oil purchase and exchange supervisor of Tide Water's western division. Hadden replaced **John W. Grendon,** recently appointed manager of the newly-created oil purchase and exchange department of the entire company.

M. T. Miller has been appointed assistant to the vice president, Government Relations and Conservation, Standard Oil Company of California has announced. Miller succeeded **S. Z. Natcher,** who has taken another assignment for the company in London, England.

PENETRATION THAT "REACHES OUT"!

"Man!, that must be an M-3 Bullet—— I never knew ole' Blue to back off from a ground mole!!"

—yes, penetration that "reaches out," deep into the pay zone, and gets the kind of results you want; peak production, more oil!—penetration you can only get with McCullough M-3 Guns and new Ogival Bullets—more than ever, "hardest shooting bullet perforators in the world."

McCullough

TOOL COMPANY

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OVER 50 BRANCH OFFICES

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Running Tour

▸ The appointment of **Marvin S. Jones** as assistant superintendent of Magnolia Petroleum Company's land department with headquarters at Dallas, Texas, has been announced. Jones has been district landman at Wichita Falls for the past four and a half years. Jones joined Magnolia in September, 1935, as a messenger for the land department's offices in Dallas after attending Southern Methodist University.

M. S. Jones

Robert W. Harless, who has been landman at Dallas, succeeded Jones as district landman at Wichita Falls. **Ralph R. Cadenhead,** landman of the Abilene district, was transferred to Shreveport, Louisiana, as district landman there, succeeding **A. A. Mason,** who retired.

Fred A. Dulaney, former district landman at Amarillo, Texas, was moved to the Abilene district succeeding Cadenhead, and **Paul L. Plumer,** assistant landman at Lake Charles, Louisiana, was promoted to succeed Dulaney as landman of the Amarillo district.

▸ Two former Stanolind engineers, **George H. Landreth** and **Bob Leibrock,** have announced the formation of partnership and the opening of offices in the Wilkinson-Foster Building, Midland, Texas. This consulting petroleum engineering firm, to be known as Leibrock and Landreth, will handle evaluation work, reservoir analyses, geological investigations, proration, property management, and well completions. Landreth is a 1949 graduate of the University of Oklahoma, and during the past five and one-half years has been employed by the Stanolind Oil and Gas Company as a petroleum engineer in their Lubbock and Midland districts and Fort Worth division office. Leibrock was graduated from the University of Texas, and has been with Stanolind in various engineering capacities.

▸ Petroleum consulting offices have been opened in San Francisco, California, by **F. A. Menken** and **W. E. Dillon,** both former officers of Tide Water Associated Oil Company. Both recently resigned from the oil company after a combined service of some 46 years. Menken, formerly exploration vice president of the western Tide Water operation, directed all petroleum exploration for that company in the West Coast and Rocky Mountain states and in Western Canada. Dillon, his associate, was assistant vice president of Tide Water Associated and vice president of Northern Light Oil Company in Alberta.

▸ **W. G. "Bill" Klassen** has been promoted to drilling superintendent of Thomas P. Pike Drilling Company, replacing **John Fowler,** resigned. Klassen joined Pike in 1947, and was formerly assistant drilling superintendent for the southern division.

▸ The addition of **Paul J. Orchard** to the geological staff of his firm was announced recently by **John W. Mecom,** Houston oil operator. Orchard, a 1938 graduate of Louisiana State University in geology, had been a geologist with American Republic Corporation in Houston since 1950. Prior to that time, he had been a geologist with the California Company.

▸ Humble Oil & Refining Company recently announced the following changes in its production department supervisory personnel. **D. C. Rhodes,** district superintendent, Goose Creek district, Gulf Coast division, was promoted to assistant division superintendent, Gulf Coast division. **R. H. Ussery,** district superintendent, Bayou Sale district, Louisiana division, transferred to the Goose Creek district to replace Rhodes.

W. J. Barrett, district superintendent of the recently discontinued Aransas Bay district in the Southwest Texas division, was transferred to the Bayou Sale district replacing Ussery. **John Paul Nolley,** assistant district sueprintendent, Stratton district, Southwest Texas division, moved to the Means district, West Texas division, as assistant district superintendent.

G. C. Pray, roustabout gangpusher, North Crowley district, Louisiana division, was promoted to farm boss at North Crowley. **John G. Jackson, Jr.,** senior petroleum engineer, Southwest Texas division office, transferred to the Louisiana division office as senior petroleum engineer. **John H. Pittman,** senior civil engineer, Gulf Coast division office, was transferred to the Gas Construction division office as senior civil engineer. **J. P. McAdams,** district petroleum engineer, North Katy district, Gulf Coast division, moved to Gulf Coast division office as senior petroleum engineer. **C. W. Armstrong, Jr.,** district petroleum engineer, Maurbro district, Gulf Coast division, has transferred to North Katy district replacing McAdams. **F. A. Keilberg,** farm boss, Thompsons district, Gulf Coast division, moved to the North Katy district, Gulf Coast division, as farm boss.

▸ North Texas petroleum section of the ASME has named as its chairman **John M. Stevenson,** Youngstown Sheet and Tube, heading its new slate of officers. **E. R. Holloway,** Atlantic Refining, as its vice chairman; **John A. Lee,** Magnolia Petroleum, is the new treasurer, and **Michael L. Rizzone,** Oilwell Supply, is secretary. **J. A. Noyes,** Joy Manufacturing, was named to the executive committee of the petroleum section. **Matthew L. Freeman,** Atlantic Refining, who has been acting chairman, was chairman of the nominating committee.

▸ **Edward B. Wasson** has joined Cosden Petroleum Corporation in Denver, Colorado, as Rocky Mountain division geologist. After graduating from Princeton University in geological engineering and earning an MS at Stanford in Petroleum Geology, Wasson was employed by the California Company for six years as a geologist and geophysicist. He was most recently division geophysicist for the California Company in Denver.

▸ Northern Pacific Railway Company has announced the appointment of **Charles F. Hunkins** as manager of geology and engineering of the oil development department.

▸ **Walter A. Ver Wiebe,** professor of geology at the University of Wichita, Wichita, Kansas, and **V. E. Monnett,** director of the school of geology at the University of Oklahoma, Norman, have been elected to honorary membership in the American Association of Petroleum Geologists, it was announced by **Edward A. Koester,** president. Honorary membership is awarded for distinguished service in the field of petroleum geology.

▸ **Hal R. Bentson** who, for the past 17 years has been with Security Engineering Company, joined Bill Seivers of Seivers Company as chief sales engineer. Bentson's travels will cover the United States and Canada in the development of the use of Oilwell Drainhole Drilling Company equipment. Bentson is a graduate of the University of California with a degree in mechanical engineering.

H. R. Bentson

▸ Appointments of engineering supervisors in two Stanolind Oil and Gas Company district offices in the North Texas-New Mexico division has been announced. **E. M. Knight** has been named district engineer at Midland, Texas, and **F. H. Callaway** succeeds Knight as district engineer at Roswell, New Mexico. Knight, a graduate of Alabama Polytechnic Institute, joined Stanolind in 1946 as a roustabout in field producing operations. Callaway, a University of Texas graduate, went to Roswell from Tulsa, Oklahoma, where he was petroleum engineering supervisor in Stanolind's general office.

▸ **Dr. P. E. Kent,** a senior geologist of the British Petroleum Company, has been awarded the Bigsby Medal by the Council of the British Geological Society "for contributions to the palaeogeography and stratigraphy of England and Wales, and his researches in Central Africa and Persia." Dr. Kent joined British Petroleum in 1936, and has been closely associated with the company's drilling program in the United Kingdom. He has also seen service in Persia and East Africa.

The Bigsby Medal was first awarded in 1887. It was founded by Dr. J. J. Bigsby, a Canadian geologist, and is awarded every other year in recognition of past work. Recipient must not be older than 45 years.

▸ Sohio Petroleum Company, Northwest division, has announced the following employee transfers in the land department. **Jack E. Lewis** has moved from Lewiston, Montana, to the Casper, Wyoming, district; **Robert F. Townsend** from Billings to the Casper district; and **James O. Smith** from Casper to the Lewiston district.

▸ An extensive drilling and development program in the Pembina field has led to personnel changes in Stanolind Oil and Gas Company's Canadian division and the creation of two new offices, the Alberta district production office at Edmonton and the Pembina area office at Drayton Valley. Heading the Alberta district organization is **C. O. Hopper,** district superintendent, who moved from Calgary to Edmonton last year. Also on the district staff are district engineer **H. W. Hinkle, Jr.,** formerly field engineer for the Edmonton area, and **C. E. McBurnette,** who has been promoted from field clerk to district clerk. **J. N. Bowman,** tool pusher, will continue to supervise Stanolind drilling in the Edmonton area.

C. F. Rakestraw, former production foreman in the Edmonton area, has been named field superintendent for the Pembina area. **D. R. Moorhead** becomes field clerk in the Pembina office. **J. H. Larson** was named field engineer. **W. M. Bogert,** who has been farm boss in the Edmonton area, has been made production foreman for the Pembina area.

Refining . . . Petrochemical . . . Gas Processing

Huge Petrochemicals Production. Quantities of petrochemicals derived from petroleum and natural gas amount to 25 per cent of our total chemical production, says Kellogg's "Hank" McGrath. In another ten years, he believes, they will make up 50 per cent of total chemicals manufacture.

To look at some of the recent high spots:

Thirty-two billion pounds of petrochemicals in 1955, estimated. Methanol (wood alcohol) synthesis at 1.5 billion lb per year, made at 1500 psig, 575-600 F.

"Synthesis (hydrogen-carbon monoxide gas" from natural gas, coal, etc., being used to supply intermediates for ammonia, methanol, urea, etc.

Ammonia is first highest tonnage in petrochemicals, ethylene second; two billion lb per year goes to polyethylene plastic, ethylene-oxide-to-alcohol (ethyl), to styrene-to-rubber.

Sixty per cent of alcohol production is now synthetic, will increase because molasses for fermentation is to go more to cattle feed.

Propylene, largely from refinery gases making about one billion lb per year, goes to alcohols, aldehydes, etc.

Oxo process for higher aldehydes from olefins and synthesis gas (H-CO), now going in three or more plants, Gulf, S. O. Indiana, and Esso, may be hydrogenated to alcohols, oxidized to acids. S. O. Indiana shipped first tank car of oxo-iso octyl alcohol from Wood River, early February.

Propylene can go to cumene to make phenol, acetone; polymerize to detergent intermediates.

Any accurate figure on petrochemicals that goes into monthly print is usually too low when published.

★ ★ ★

Spot-Lighting Shale Oil. Several refining companies are researching on shale oil and one, Union of California, is building a complete system on 50,000 acres of its own oil shale land near Rifle, Colorado, the point where the U. S. Bureau of Mines has done such an outstanding job of large-scale research, a project now abandoned by the Bureau. Union has developed a shale retort for oil recovery. Now Union plans a 1000 tons-per-day shale retort, will carry on research on the mining and refining of shale to obtain cost, yield, and processing data. At published figures these 1000 daily tons will yield 30,000 gal crude shale oil, available for research. Union has an estimated total of five billion barrels of shale oil, will spend $5 million.

Other companies, especially The Texas Company, are doing research work. Shale oil, they believe, must be brought to the point where it competes commercially before it can be utilized economically on a large scale. Estimates have been made by some economists that shale-derived gasoline can be made and delivered in southern California at about the present refinery price, around 12 cents. National Petroleum Council and Bureau of Mines earlier estimated the minimum practicable refinery size to be 50,000 bbl per day for shale oil, to cost $330 million at today's prices.

★ ★ ★

India's First Refinery. The $32 million refinery of Stanvac at Bombay, India, was opened recently "with pomp and ceremony," and is considered "a landmark in the industrial development of India" according to Production Minister Shri K. C. Reddy of the Indian Government. Indian capital is said to hold 25 per cent of its stock. Plant now is processing about 25,000 bbl of crude daily which will be increased greatly, to "300 million Imperial gallons," (350 million U.S. gallons) annually at full operation.

★ ★ ★

Sinclair-Standard Ammonia Team. Standard Oil of Indiana and Sinclair Refining Company have formed a jointly owned company, Calumet Nitrogen Products, to build a 300-tons per day ammonia plant at Hammond, Indiana. Plant will be finished about mid-1956, will use byproduct hydrogen streams from both company refineries.

★ ★ ★

Supersonic Powerplants. Lubrication of supersonic powerplants is rapidly becoming one of the most insistent problems of aviation engineering. Now comes Southwest Research Institute at San Antonio, Texas, with new synthetic lubricants that *may* lubricate and withstand the extremely high temperatures in engines moving aircraft twice as fast as the speed of sound—that is, up to more than 2000 ft per second, as fast as military rifle bullets traveled only decades ago. It seems the scientists think they have two or three new phosphoric acid derivatives as lubricants that will withstand the above-500 F temperatures of supersonic powerplants.

New Contactor-Extraction Process. A new system, the rotating disk contactor, developed by Shell Development Company was explained to members of the American Institute of Chemical Engineers at that society's New York meeting. A single commercial installation, in Shell Haven refinery, England, shows in a tower of 16 ft - 8 in. height an extraction efficiency equal to that of a packed tower more than 100 ft high, or six times the extractive efficiency. The unit is a multi-compartment tower with stator rings at intervals, between each pair of which a rotating disk is mounted on a vertical shaft.

Extraction of lubricating oil fractions with selective solvents is one of most important applications. Another use now is the separation of chlorinated hydrocarbons, removal of mercaptans, and similar uses. Licensed engineers and builders of the process are the Lummus Co., and the Turbo-Mixer division of General American Transportation Corporation.

★ ★ ★

Electronic Still Foremen. A high-speed electronic "brain" is being installed in Socony-Vacuum's Paulsboro, New Jersey, laboratories and is being "groomed" to operate processing units directly. It seems that with a mathematical model and cards recording process unit characteristics, and numbers and formulas representing the units, the whole works is started and operated by feeding the cards into the machine for making calculations and initiating the necessary steps to run the refinery. Wonder what kind of lubricating "oil" this "brain" requires? Soon the ASTM, SAE, or API will be called on to set up specifications for brain oil.

★ ★ ★

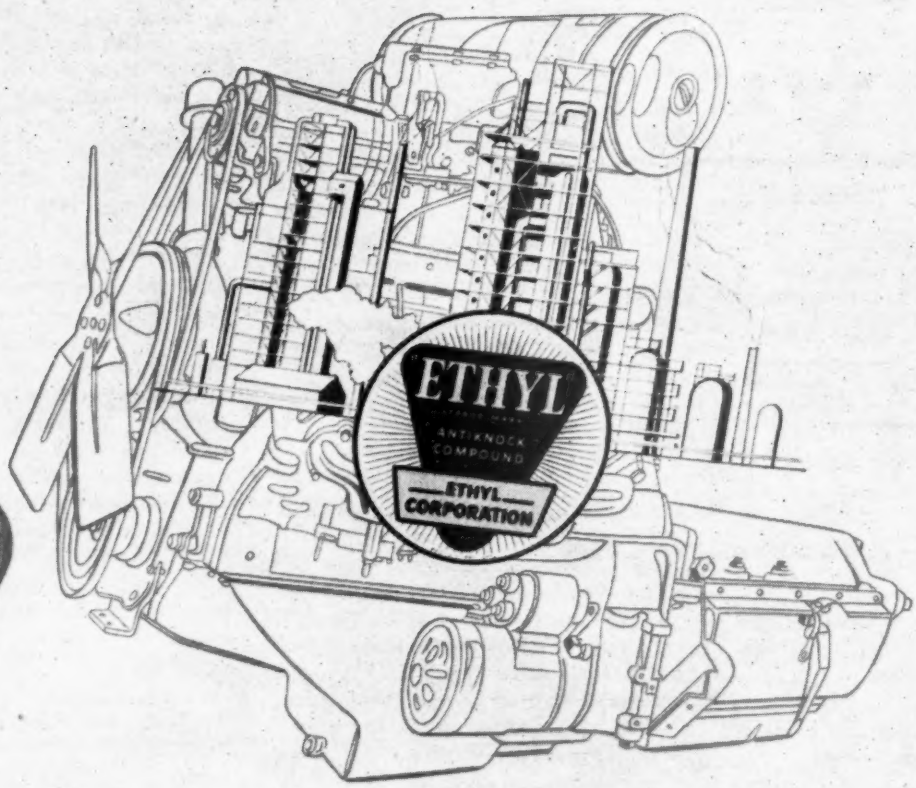
Clean Up France? Societe Shell Saint-Gobain at its new plant at Petit-Couronne, France, is said to be producing detergents at the rate of 25,000 tons or more annually, as one of the products from its refinery brought on stream recently.

★ ★ ★

More Fast Tax Write-offs. Among recent tax write-offs recorded are one at Baltimore, Maryland, for Catalyst Research Corporation, $40,000 at 45 per cent; and Ethyl Corporation's two new jobs, a $450,000 addition to the Baton Rouge, Louisiana, plant and a $650,000 laboratory at Ferndale, Michigan, near Detroit, where Ethyl's main laboratories are located.

XUM

ROAD BEHAVIOR
OF
COMMERCIAL PREMIUM FUELS
1954



ETHYL CORPORATION

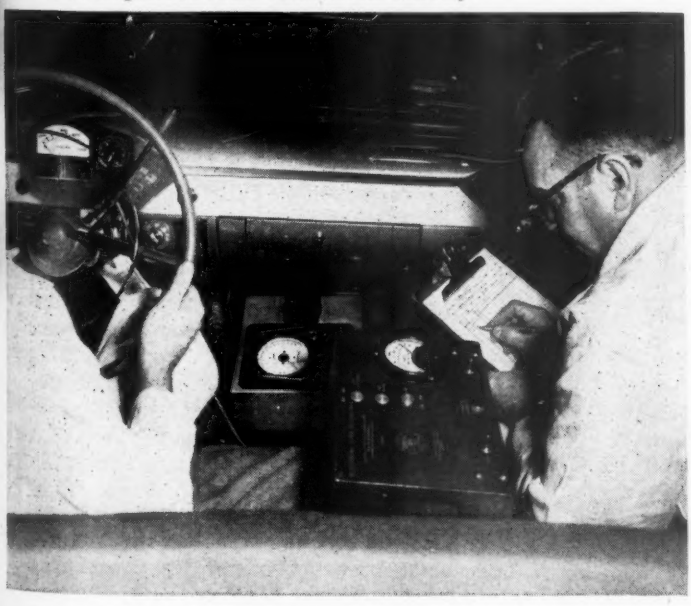
Report on road behavior of many American premium gasolines is available in this Ethyl study.

Ethyl Research shows refiners how the nation's fuels behave on the road

Refinery technology report shows ratings of premium fuels in 8 representative cars

Control room of one of Ethyl's all-weather facilities where engineers create reproducible road conditions right in the laboratory.

Representative car used in Ethyl's road testing is subjected to temperature, humidity and load changes that duplicate road conditions exactly.



In this 100-page booklet you will find 144 charts and graphs and 77 pages of detailed analysis showing how the nation's premium gasolines perform on the road.

This booklet is the latest addition to Ethyl's continuous study of the road behavior of gasoline designed to help you in the evaluation of your gasoline. In order to give you a cross section of the nation's premium-gasoline qualities, we periodically run a large survey in which we investigate the antiknock characteristics of base stocks for premium fuels.

In this survey, more than 60 gasoline samples were tested, representing 70% of the base stocks of the premium gasolines sold in the United States. More than 1,000 chassis dynamometer tests were made on eight different cars in Ethyl's unique controlled-weather rooms. In addition, more than 15,000 octane ratings and other tests were made in the laboratory.

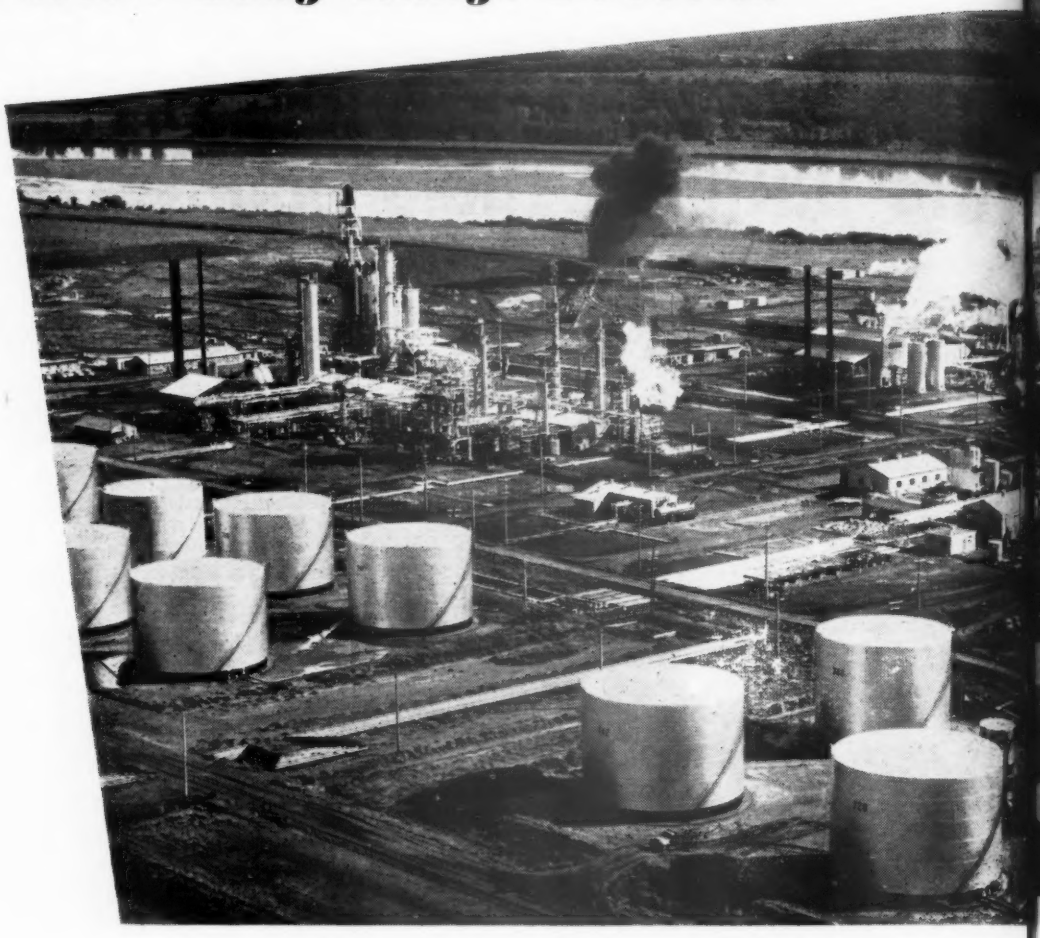
The type of experience we have gained in preparing this report is but one of the tools our refinery technologists have to assist you in improving the road behavior of your own gasolines.

If you would like a copy of "Road Behavior of Commercial Premium Fuels—1954," see your Ethyl representative. He'll be glad to see that you receive a personal copy.

ETHYL CORPORATION
Research Laboratories
1600 West Eight Mile Road, Ferndale 20, Michigan
2600 Cajon Road, San Bernardino, California

XUM

Industry's No. 1 Long Range Problem



P 701.

POWER

Arch L. Foster*

More Fundamental Research Is Ever-Present Demand, a "Life-Saver" for All Chemical Progress

EXCLUSIVE

THE greatest single, long-range problem of industry in general and the petroleum industry in particular is that of an adequate supply of power for the future, industrial leaders appear to agree. The most obvious way to guarantee plenty of power is via nuclear—atomic—energy, it is said, a matter that still requires some solving of major and minor problems.

Harnessing solar energy is another finitely inexhaustible source of power, mentioned especially by Shell Chemical's M. E. Spaght, who says that "fossil fuels" (petroleum, shale oil, coal) will be used largely as chemical raw materials within another half-century. In the long-haul, the human race will need so much energy that the entire resources of the earth will be pressed to supply it. Nearer in the future, in addition to atomic energy, the utilization of huge quantities of coal, also of shale oil, will solve the problems as they arise. The "fuel cell" is being boosted by the Manufacturing Chemists Association, with a claimed 80 per cent efficiency that will conserve presently employed energy sources.

More immediately, the industry needs a bigger "crop" of trained engineers, chemists, and scientists of all types. The output of technical and scientific school graduates is not increasing fast enough; even the higher pay allowed technical graduates as compared to non-technical graduates apparently is not drawing students into the scientific field in the required numbers.

Shortages Are Relative

While power shortages are actually non-existent as of now, the shortage of technical people is imminent. The first

*Editor, Refining and Petrochemical edition.

The spanking-new 30,000-bbl Standard of Indiana refinery at Mandan, North Dakota. Plant is connected via pipe line with nearly 2200 miles of company products pipe lines, in the middle western areas.

also the required refining methods needed, especially the effect of hydrogenation on product quality and necessary refining methods. These advances have been so satisfactory that, according to announcement, Union Oil Company of California, which has done much research on a retort that will give the best distillate from oil shale, and on refining methods, is building a large-scale experimental unit in the Rifle, Colorado, area where the Bureau's activities have been concentrated. This work, if followed to its normal conclusion, may be expected to supply the industry with applied technical information leading to the conversion of shale oil to competitive products within the foreseeable future. This does not mean, necessarily, that the refining industry will begin soon to refine products in commercial quantities from shale oils.

Technical Men Preferred

Nearly 100 industrial companies have said recently that they will pay more to technically trained men without previous experience, than they will pay non-technical graduates; from $350 to $400 are offered for bachelor degree men. Seven of these companies will pay PhD graduates $425 to $450; nine companies will pay in that same range for master's degree graduates. The majority of companies asking for PhD's say they are willing to pay varying salaries: 7 of them, $476 to $500; 11, $500 to $525; 21, $526 to $550, and 12 up to $575, with five exceeding even that figure. *(C.&E.N., 1-24-55).* College enrollment in technical courses is up; however, fewer students receiving BS degrees in chemical engineering will graduate in 1955 than in 1954; therefore, the number of graduates in 1956-59 will increase, it seems safe to prophesy.

Immediate Problems Also Insistent

The immediate problems of making refined products are no less vital, but demand a solution "yesterday," so to speak. Looking at the near future, one of the gravest problems is that of "How high octane ratings shall we supply?".

The last motor gasoline survey (*The Petroleum Engineer,* p. C-60, Feb., 1955) shows only fractional octane number gains over the October, 1954, survey. *Each survey in the last three years has shown the same degree of octane increase, however.* This indicates that the march is, inexorably, up-

New electronic computer "mechanical brain," installed for Socony-Vacuum Oil Company's Paulsboro, New Jersey, research laboratories.

must be solved over a long period, several decades at least; the second is pressing and cannot long wait for a better solution.

As of current activities, look at the recent advances in all the fields mentioned above. Standard Oil Development Company is building an atomic reactor at great cost, to do fundamental research in this field. Doubtless other large oil companies will follow, or are following, this example in the relatively near future.

As to shale oil, for several years following its initial venture into oil shale in the 1920's under the late M. J. (Mike) Gavin, the U. S. Bureau of Mines has carried on large-scale experimental work in western Colorado in the richest of the oil shale deposits. The Bureau has achieved far-reaching results, especially in determining the optimum mining conditions and costs,

XUM

North Burnaby, British Columbia, refinery of Shell Oil Company, 15,000 bbl per day capacity, at cost of $15 million, started in 1954, to supply Pacific Coast demands of Canadian consumers.

ward in both regular and premium motor fuels. Engine horsepower is also climbing. Even though Dr. C. F. "Boss Ket" Kettering at the meet of the Society of Automotive Engineers in Detroit in January ridiculed kindly the claims of the engine makers for huge horsepower ratings in current engines, the fact remains that these engines, via their boosted compression ratios, demand higher octane number fuels. It is somewhat academic to inquire whether the engine, and the car, need these greatly augmented power ratings. Kettering pointed out, with tongue in cheek, that the maximum horsepower rating of a given engine (250 bhp) could be obtained from it at a speed of merely 135 mph, "and that can be attained by practically anyone."

Fact remains that these engines are sold and it is up to the refiner to produce the fuels that are called for. Therefore, competition, not engine demands, is forcing the refiner to make fuels of higher and higher octane numbers. Whether or not that procedure is economic is beside the point. The refiner must make fuels of competitive qualities, or else.

"Aviation fuels" is the field where the "water" is being muddied—plenty. Higher octane rating fuels for reciprocating radial engines are no serious problem. Our catalytic cracking, reforming, alkylation, and isomerization processes are quite adequate, in results and in capacity, to take care of all needs. Reciprocating engines for commercial purposes are still in strong demand, therefore conventional fuels for them also are currently in demand.

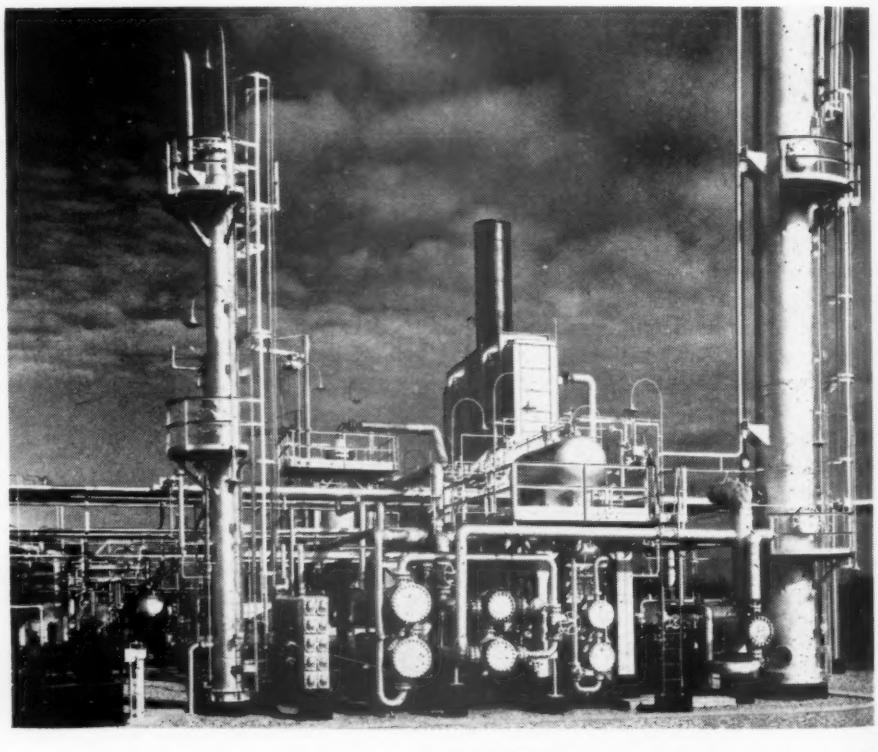
Jet Fuels Serious Problem

Jet fuels, demanded in large quantities by military aircraft engines and coming somewhat rapidly into prominence for commercial planes, especially in England, constitute the variables in the eternal equation of new fuels. The current JP-4 fuel, as specified throughout the Western World, is considered to have the best combination of properties of any fuel yet specified. One of the supposedly important factors in jet fuels is the safety factor, yet authoritative sources say that the kerosine-type fuel is probably as hazardous as is current aviation fuel, due largely to its greater creep tendency.

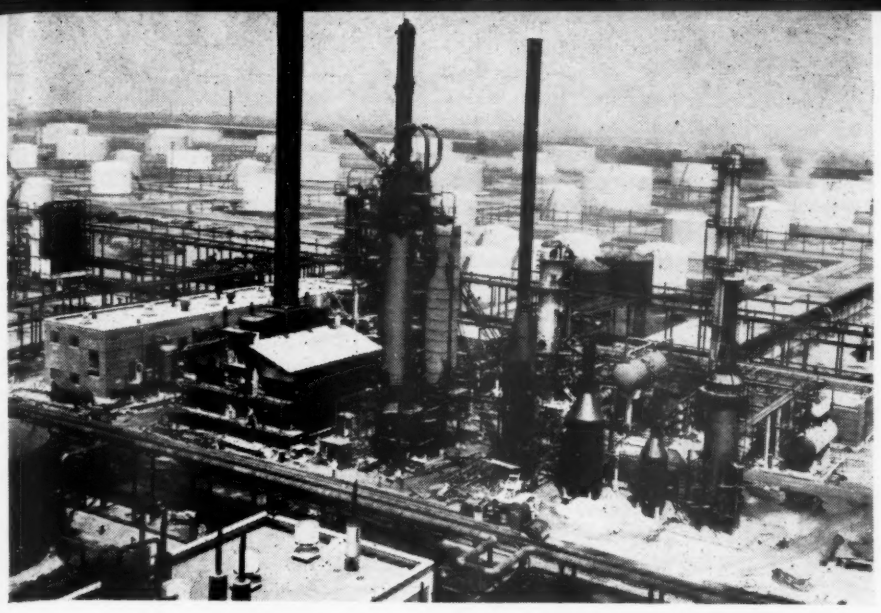
Therefore, refiners are faced with the problems of recovering adequate quantities of the JP-4 or other jet fuel types from existing crudes, and at the same time being able to supply required amounts of the other fractions called for by current market demands. The whole situation means a collaboration between the jet engine manufacturers and operators and the refiners, to find out what the jet engine actually requires. Engine efficiency calls for a fuel so good that no troubles will come under any conceivable conditions; this fuel will cost too much. Economy dictates that the jet engine use the cheapest fuel possible, so it will be obtained from the widest fraction in the crude with the least amount of refining, with the highest Btu per gallon that can be converted into useful power, and having the least operating hazard.

Lubricants Aid Fuels

The lubricating oil division of the modern refinery must deal with two major developments. The first is the very important increase in the viscosity

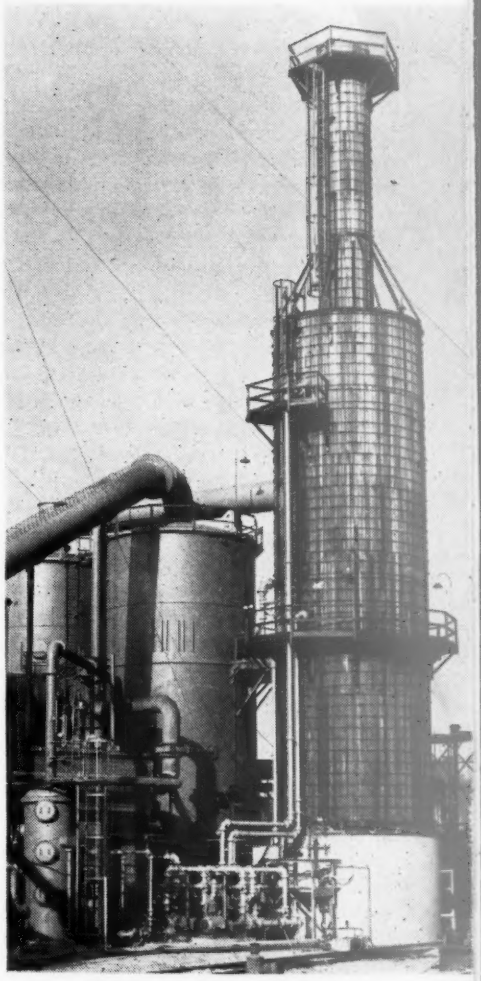


A platformer unit of Skelly Oil Company, at Longview, Texas, operating on the same catalyst charge for more than two years, making motor fuel component and/or aromatics for petrochemicals, avgas.



This unit, the second fluid hydroformer in the world, will be completed for about 13,000 bbl per day capacity, by Kellogg for Cities Service Oil Company at East Chicago, Indiana.

Sulfur dioxide unit, for the recovery of sulfur and production of sulfuric acid by the Cominco process, at Pasadena, Texas, for Olin Mathieson Corporation.



index of these oils, whether attained by refining methods in the segregation of the high VI fractions of crudes, or by the use of any number of addition agents, employed for the improvement of the different properties of the original, refined hydrocarbon materials.

Improvement of viscosity index—that property that indicates how slowly or rapidly an oil loses or gains viscosity with elevation of temperature, or vice versa—can be accomplished directly by more and more careful solvent extraction to segregate the highly paraffinic—high VI—hydrocarbons from the lower VI, more aromatic constituents of the raw crude fraction. Thus, the highest VI attainable is determined first by the composition of the crude and then by the yield required from that crude; the higher the VI demanded, the lower the yield by solvent extraction.

This is where additives come in. As of now addition agents are employed widely to increase viscosity index, to raise oxidation resistance, and to improve "detergency" that is, to better the ability of the oil to hold in solution or suspension the decomposition products from the oil and the fuel and thus prevent the deposition of these materials in the engine where they will do the most harm. Such properties as load-carrying capacity, film strength and heat resistance are also of paramount importance and are promoted in great measure by adding various chemicals.

The result of all these demands is two-fold: The multigrade oils now being marketed include all of the old conventional SAE grades that serve for all purposes, summer and winter alike, without thickening or thinning too much, thus maintaining the load-carrying capacity satisfactorily. These oils have solved much of the whole problem so far as automotive engine oil needs are involved.

For jet engines and similar services, the picture is entirely different. It was determined long ago that the best service cannot be obtained from conventional petroleum-derived lubricants. Engine operators, then, must turn to lubricants of synthetic liquids, to solids or to gases—air—to carry the bearing loads at the extreme engine temperatures encountered in present-day service. Of the synthetics, researchers (NCAA) have found that up to 200 F higher temperatures may be maintained in the engine and still obtain satisfactory lubrication. Among these synthetics are diesters, especially silicone diesters. These show proper lubrication at temperatures of the order of 700 F, well above any petroleum product, while possessing low temperature properties satisfactory at well below zero F operating conditions. The silicone-diesters show better temperature-viscosity characteristics (viscosity index) than do the petroleum products and only moderately lower VI than diesters, with greater temperature resistance.

The most efficient lubricants for the temperatures up to 1000 F are the ubiquitous powdered graphite, used for a long time as a superlubricant for certain conditions, and a more recent newcomer that is finding wide application, molybdic sulfide, MoS_2, also a black powder. One of its special uses is in the manufacture of highly specialized, ultra-exacting instruments such as geophysical, etc. Bearings of a highly specialized design lubricated with high-pressure air are being studied but are still very much in the "test tube" research stage. The typical attitude of the informed researcher in these fields may be expressed fairly well by "We ain't seen nuthin' yet."

Elsewhere in this issue (Larson, p. C-44) a more detailed summary of the types of addition agents, their uses, purposes, and applications in all sorts of lubricants is presented.

Processing — In 7-League Boots

Process-wise, catalytic operations still lead the field, and justly so. Catalysis is the "Philosopher's Stone" that offers ability to change properties, yields, and radical conversions to a greater and more useful degree than any other "tool" the refiner has obtained. Probably the first large-scale catalytic operation in the industry was the aluminum chloride "cracking" of middle-distillate fractions to make gasoline, a process now outmoded; yet the same "catalyst" is still applied to a different type of molecular change in the production of one of our most outstanding lubricating oil brands.

Catalytic cracking and reforming overshadow strongly all other processes now in use in the refinery. With the summary article on these operations

elsewhere in this issue are lists of units for both processes, the sum total of the cracking capacity being greater than our remaining thermal cracking capacity, by 2,830,000 bbl to 2,570,000 bbl, according to figures published recently.

These two processes are responsible largely for the refiners' ability to meet the slowly but surely rising demands for higher octane ratings. These ratings already in prospect for the not distant future will equal the ratings of military type aviation fuels at the start of World War II. With 100-octane number fuel, it has been demonstrated conclusively that automotive engines of 12.5 to 1 compression ratio are feasible for general distribution. In any case such engines have been operated on the road over a wide territory satisfactorily, with efficiencies in miles-per-gallon and power output approaching that of the diesel engine.

In the interest of sound economy it must be remembered that these supermotor fuels can show corresponding economy only in engines designed for them, otherwise a waste of "octanes" is inevitable. By controlling catalytic cracking conditions and by care in cutting the motor fuel fractions to give increased octane ratings, these ratings may be increased far beyond the present octane scale; witness the aviation superfuels in use during the last ten years and longer. But these advantages are accompanied inevitably by corresponding losses, reductions in yield, and raised refining costs. If economy is to be attained in proper measure, these added costs must be offset by higher engine-fuel efficiency, otherwise the industry and the customers both lose.

Another important and potentially huge segment of the catalytic cracking-reforming field is that of the production of raw materials and intermediates for petrochemical manufacture. During the 1942-46 period one of the most important and critical products from catalytic cracking was the production of two materials for synthetic rubber-butylenes for the making of butadiene, ¾-component of the then GR-S type of synthetic rubber; and ethylene, reacted with benzene via the Friedel-Crafts reaction to yield ethylbenzene, dehydrogenated to styrene, the 1:4 component of GR-S rubber that saved World War II for the Western Allies.

This synthetic rubber-plastics field is calling continuously and loudly for more components; olefins, as ethylene, propylene; diolefins, as butadiene, pentadiene, cyclopentadiene, and similar acetylene across the board. The synthetic rubber plants, according to most recent news dispatches (as of the date this is written), are going into private hands, one of the happiest developments in the entire industrial picture of the "Free World." Private interests, private initiative, private research, private company "risk" capital that chances its losing in order to achieve new things "through chemistry" (with thanks to du Pont), the savings of private individual stockholders who risk their savings in an effort to accomplish results never before known—these are the things that accomplish the seemingly impossible in our economy. Already we have developed rubbers of numerous sorts far improved over any natural products—neoprene, butyl, etc.—and the raw materials will and must come from petroleum, natural gas, or other hydrocarbon sources—shale oil, hydrogenated coal, the Fischer-Tropsch synthesis of chemicals and hydrocarbons from carbon monoxide and hydrogen, "The greatest single reaction discovered in chemistry since oxygen."

Improved Processes Multiply

In a long list of processes developed and underway in recent years, most of which have been announced quite recently, may be mentioned Union Oil's Unifining, by which a cobalt molybdate catalyst eliminates sulfur, nitrogen, (*The Petroleum Engineer*, Sept., 1954, p. C-64). The Hyperforming process of Union Oil Company of California is probably the most recent of the catalytic reforming processes, and as yet only one unit for this process is under construction on the West Coast.

The fluid principle has been applied by Standard Oil Development Company to the adsorption field, its newly announced Fluid Char Adsorption process, by which finely divided, fluidized and activated carbon is employed to adsorb petrochemical components selectively, for example, from refinery vapor or liquid streams via countercurrent operations. A pilot plant for recovery of C_2's and C_3's from refinery gas been operated satisfactorily. Other applications are under study, and the process is to be licensed to the industry.

A new rotating disc contactor (RDC) has been announced by Shell Development Company for use in bringing into intimate contact two or more streams for any given purpose or to effect any given reaction. The new system offers use in such fields as caustic or solutizer treatment of light distillates; aromatics recovery or concentration; separating liquid organic materials, deasphalting, etc. This system also is to be licensed to the industry. It consists of a vertical cylindrical tower, already built in diameters of 2 in. to 7 ft. In the tower is a rotating shaft to which are fitted at intervals smooth flat discs of diameter about half that of the tower and which give "gentle but effective agitation" to liquids passing through the tower. Between these discs are fixed rings, attached to the tower's inside wall and having internal diameters greater than that of the discs, which break up the tower into compartments in each of which a disc is rotating. Heavy liquid enters at the tower top and goes out at the bottom, countercurrent to the lighter of the two liquids, which enters at bottom and goes out at the top. The process lends itself to any typical countercurrent flow system for intimate contact between streams, such as solvent extraction, treating distillates with chemical solutions, etc. It is to be licensed to industry.

Probably the greatest cooperative applied research task yet undertaken by the refining industry is that of Fractionation Research, Inc., a non-profit effort by 43 chemical and petroleum organizations to develop greater know-how in the principles of fractionation of hydrocarbons. This group, with a research staff at the plant of C. F. Braun Company, near Los Angeles, California, met last November in that city to plan and formulate the second phase of this far-reaching fundamental research program, the purpose of which is to discover more basic data that will enable the industry to revamp existing equipment for greater efficiency, and to design new equipment for less cost, greater flexibility and reliability, and to give more effective service.

Space is not available to mention all of even the most important activities of the refining and petrochemical industries. A heartening step of far-reaching potential import is that of Union Oil which, having spent a great deal of time and money is developing methods and equipment for recovering oil from oil shale, is planning a large-scale shale oil plant in the vicinity of the Bureau of Mines' shale mine and pilot plant near Rifle, Colorado. Union Oil will undertake with its own staff and capital to develop a greater fund of data on the recovery and refining of shale oil for the future utilization of this tremendous hydrocarbon resource. Some of the Bureau work will continue, especially in refining the oil and in adapting it to product manufacture.

Also, it is understood that a Canadian company has been organized and is to undertake serious work in developing better methods for recovery of the heavy oil or "tar" from the tar sands of Athabaska and elsewhere in Canada. Considerable work has been done on this project in past years but it has not yet been attacked by a group with sufficient funds and manpower to make of the effort a major project. Huge quantities of these heavy fractions are obtainable from these sands by mere solvent extraction and if an

economical method for this step is developed it will add greatly to Canada's available supply of petroleum-type hydrocarbons.

Automation Shows Progress

A condensed report in this issue (See Schlegel and Ross, p. C-37) that gives the high spots in our trend toward actual automatic control of refinery processes. Electronic transmission of control action by instrumentation, and the attendant developments give the greatest promise in this all-important field in process operations. Economic considerations now overshadow those of safety, which purpose earlier was the main theme of automation. This principle is not for the purpose of reducing the number of employees, says Standard Oil Development President E. G. Murphree. Full automatic control may well increase the personnel needed in a given plant. Of course the primary purposes of automation are two-fold: To obtain the quick and exact response of control to changes of conditions and to maintain the process in the same state of operation, quicker than the human, manual control can accomplish that result; and to free human operators from routine for more exacting jobs that require the direct attention of the human brain. Safety is still very important but now is taken more as a matter of course.

Plants that two decades ago had less than 1 per cent of their total investment in instruments now average 7 to 8 per cent. Coming forward rapidly in research is the development of continuous analysis equipment and methods by which operations can be controlled through very rapid determination of the yields obtained in the product stream itself, by finding out the percentage of the desired raw material found in the stream going to or from reaction zones.

Petrochemicals Still Climbing Hill

The current and future prospects for petrochemicals are covered in greater detail elsewhere in this issue (See Mares, p. C-12), but recent statements place our output of these products at 32 billion lb for 1954. It is estimated by competent authorities that this figure overall will increase by 150 per cent by 1975 or up to 75 billion lb annually. Yet this astronomical quantity will be attained by the consumption of only about 2 per cent of our oil and gas production as of any given date, so that our petroleum industry economy will not be ruffled appreciably by this demand. There are those, also, leaders well acquainted with the situation, who prophesy that much of our petrochemical finished products will derive from shale oil rather than petroleum and natural gas *per se*. This is not unthinkable, since shale oil contains large quantities of olefins, diolefins, and organic nitrogen, sulfur, and oxygen compounds. Published figures indicate that petrochemicals make up 25 per cent of our entire chemical output.

Production of nitrogen organics for fertilizer, largely, is one of the greatest petrochemical fields. U. S. Department of Agriculture has estimated a production of 2,200,000 tons of nitrogenous fertilizers in this country for the coming fiscal year, more than the 1,970,000 tons of potash, and nearly as much as the 2,350,000 tons of phosphates to be produced for U. S. fields. Recent estimates show that manufacture of ammonia from catalytic reformer gas—hydrogen-rich excess gas—is cheapest of all sources, with a $5,000,000 investment and $29.34 per ton for manufacture, [*Chem. Eng. Prog., 51,* No. 1, p. 17-J (1955)], in a 200-ton-per-day plant. By comparison, from coke-oven gas the per-ton cost is $35.01; from natural gas, $41.25; from fuel oil, $44.16, and from coal, $46.51.

The costs and the results of research are of all-out importance to the chemical industry. It is estimated *(C. & E. N., 1-3-55,* p. 14) that in 1955 the industry will spend a tidy $57,000,000 for research *facilities*. A round $1.5 billion in new construction is under way; last year the Gulf Coast and the South-Southwest spent a billion dollars for new building, more than half of that in Texas, largely the Gulf Coast.

"The products of research," says W. C. Foster, Manufacturing Chemists' Association president, "have permitted the chemical industry to expand fourfold over the past 15 years." Thus we are approaching the prognosticated quadrupled 1950 production by 1975. A sales total of $18.6 billion aided the industry in 1952; 1953 saw this figure grow to $19.8 billion, and it is believed 1954's totals will be about the same value. One of the "virgin" territories is that of Alaska and the northwestern area of the continent, especially for fertilizers. Ammonium nitrate costs $154 per ton delivered from British Columbia to Alaska. Making ammonia locally and reducing the cost to 40-50 per cent of that would enable the Alaska farmer to make that territory self-sustaining, food-wise and to take advantage of the short but rapid growing season.

Personnel Problems Still Acute

No single problem is so insistent, and sometimes so acute, as that of qualified, trained scientific and engineering personnel. As stated, the "going" pay rates for technical graduates are higher than for any non-technical type of college graduate. The number of freshmen who are enrolled in scientific schools is 9 per cent greater this year than last, one of the few promising signs. Too few college students go in for engineering and scientific courses. A great number of our pre-college training schools—high schools, etc.—have very inadequate preparation for college science work. Then comes that bugbear of so many facets, that Russia is putting out several—about four—times as many technical graduates as we are. One commentator alleviates the matter somewhat by saying that the quality level of training is "uncertain."

All qualified leaders agree in essence that the most important phase of our needs for science training and for research is that we must have more fundamental research. Otherwise we shall soon find an "empty barrel" where the fundamental scientific facts come from. From these we have been drawing in the past and largely at present. For decades we have been drawing on fundamental chemical knowledge storehouses in Europe but the advancement of applied chemistry is based on an increasing knowledge of the fundamentals on which applied science must be developed. To advance this knowledge "border" we must carry on more and more research of a fundamental nature, say industrial leaders.

An interesting detail is that in addition to other construction mentioned above, government-financed building, mostly by contracts with chemical companies, now amounts to $3.3 billion currently. At the same time the synthetic rubber and rubber intermediate plants are under contract to be sold to private companies, which latter will take up the burden of producing rubber in adequate amounts. Twenty-five of the 28 plants have been contracted for sale, subject to final approval or rejection by Congress. Only the great copolymer plant at Institute, West Virginia (not yet modernized), the modern copolymer unit at Baytown, Texas, and the butadiene-from-alcohol plant at Louisville, Kentucky, had not been contracted for as of January 1, 1955. Seventeen prospective buyers are companies in which refining or petroleum chemical companies are interested.

Rubber consumption in 1954 dropped from 1.34 million tons in 1953 to 1.2 million tons in 1954. It is interesting to note, however, that more synthetic rubber (627,000 tons) was consumed than natural rubber (588,000 tons), with 500,000 tons of GR-S (tire type) synthetic rubber alone being made. Natural rubber production trend is continuously downward, from 1,885,000 long tons in 1951 to an estimated 1,725,000 long tons in 1955. *(C. & E. N., 1-10-55,* p. 108). * * *

XUM

PETROCHEMICALS TO YOU

ACT I

Place: *Luncheon meeting of the board of directors and officers of Master Petroleum and Refining Company.*

Time: *1946 immediately following annual stockholders meeting.*

ACT II

Scene I

Place: *Stockholders meeting Master Petroleum and Refining Company.*

Time: **1953**

Scene II

Place: *Luncheon as in Act I.*

Time: *Early afternoon following 1953 stockholders meeting.*

Joseph R. Mares*

ACT I

President and chairman of board: Gentlemen, suppose we get started. I must leave this meeting early today; the officers of the Zeta Chemical Company are here this afternoon for a discussion. You know we are looking at that company. (pause)

In reflecting on the stockholders' meeting this morning and particularly some of the questions that were asked, it is clear to me that our business is not well understood by the average stockholder. We are in the oil business. This fertilizer business, atomic energy, rubber, plastics, chemicals, nylon and all that—our stockholders seem to think they have invested in a budding industrial trust or investment fund of some sort or other. Frankly, the trouble facing the Master Petroleum and Refining Company is that we have so many needs and opportunities to keep up in our own field, that we can't go out looking for some new pasture. Alec, you handled very well that woman's question on whether we are going to produce fertilizer. You noticed that the woman next to her asked about making nylon and selling stockings through the service stations.

Alec Freo, vice president, production: Her husband runs an independent filling station in Jersey. She told me he handles our oil. Boss, you sort of put me on the spot with that fertilizer gal. Strictly speaking we don't produce anything that doesn't already exist. All we can do is pump it out, that's why I suggested in my answer that probably the refinery representatives be invited to comment.

President: But she understands now that our business is to get things out of the ground, whereas the fertilizer folks are putting stuff back.

Freo: We are trying to put water back into the ground and get oil out, but it didn't occur to me to mention that.

President: I'm glad you didn't. Some of our royalty owners keep asking why we don't get more oil out of some of those old fields. And boys, that's coming—we're got to be prepared for it.

Alec, you did so well with that fertilizer lady that I turned the rubber question over to you, too.

Freo: Well, that one was right down Jack's alley, and I hope I did not embarass you or the board members by suggesting that he comment.

President: No, that was the right thing to do. Jack?

Jack Kracker, refining vice president: Boss, frankly this job of getting the government avgas facility integrated into our motor fuel production, adding to our lube oil capacity, the Canadian refinery design, not to mention getting squared away with all those so-called cheap sour crudes that we have had to run, to mention only a few items, have helped to keep me from worrying about the Rubber Reserve, let alone the possibility of making synthetic rubber. Incidentally, Rubber Reserve is in again for a contract for B-B* and I want to talk to the executive committee about this after the marketers decide what our house brand octane will be this summer.

President: I thought you handled it very well. Natural rubber is coming in again and in another year or two those plants may be in moth balls.

As I was telling you last night, Major, we're not passing up any bets that will help us get into this petrochemical field. We're lookin' at everything that can put us into this chemical show. Jack's got it on his mind—we're all thinking about it.

Kracker: We turned down two chemical projects at the board this past year. Both showed better pay outs than the cat cracker that we approved. I am satisfied we were right in turning them down—we had to have the cat unit to stay in business and we were better

*Petroleum consultant.

*B.B. = Butane — butylenes fraction—Ed.

EXCLUSIVE

Decision to enter petrochemical industry requires exhaustive study of controlling factors, good judgment in evaluating them

off putting our spare funds into more production.

It may be that if we really want to bull our way into that industry we'll have to look at a lower return than we would like in order to get our foot in the door—as a start—and figure that other projects will fit in later that show a better pay out. Or maybe some sleeper in the form of one of these government plants will turn up that may look good.

Major Drake, outside director: How important is this Rubber Reserve business to the operation of the refinery on the Gulf?

Kracker: The way that alkylation operation has settled down the costs are where we always thought they should be. During the war, of course, C_{48} went partly to Rubber Reserve and the other to aviation fuel. We have the capacity of the alklyation unit up to a point where all our C_{48} can go through alkylation without selling *any* to Rubber Reserve.

To answer your question it's just a matter of economics and competition; as we are now operating we really don't need the alkylate except for aviation fuel and can get along if we continue to sell some of this fraction to Rubber Reserve. We can get along either way.

Drake: What would you do if Rubber Reserve had a contract with you and the marketers wanted more house brand octane?

Kracker: Just off hand I would say that we would use some more lead or crack a little deeper in the Cat unit, which we can do at the expense of catalyst. This would give us more C_{48} and a little higher octane numbers in the gasoline boiling range.

If we have to continue to run that sour-dough crude we may find ourselves in a bind.

Freo: Well, don't expect crude prices to go down.

Drake: The reason I asked about Rubber Reserve is that I was told at a small luncheon a few weeks ago that the natural rubber production is not going to recover prewar volume quickly, if ever, due to the unrest among the Far East natives.

Kracker: Major, unless the demand from Rubber Reserve gets out of control, which I don't see because their facilities for butadiene and rubber are limiting, we won't be hurt. In any case, so long as the government is running that show all the refiners must contribute a share of their butylenes.

President: Say, what do we have in plastics? You remember that little fellow—I forget his name—he represents some investment house in Boston, asked if we are looking at plastics. Mark, you had some oil cans made of plastic on test—I should have referred that question to you.

Mark Upp, vice president, marketing: I'm glad you didn't. After we spent I don't know how much trying to get a package that the filling station attendant could handle and would stand the knocking around in transit, *we found that the package cost more than the oil.* So we decided that until oil is sold because of the package we'd better forget the plastic idea.

President: Well gentlemen, we've got to keep this chemical thing in mind, the stockholders read the slick magazines and in any case it may have something that we ought to consider. By the way Jack, what happened to that carbon black proposition that we talked about a few months ago?

Kracker: That report is just about ready, but I can give you a brief run down now:

The old carbon black is based on natural gas; it has been losing markets to the newer oil blacks, which are cheaper and better in both natural and synthetic rubber tires. With the prices of natural gas going up, even in West Texas, and prospects of it going higher, the days for the old channel black appear to be definitely numbered.

Now as for the oil blacks that are made from heavy distillates—you know we enjoy a rather good outlet at our Mid-Continent refinery for this use. If we move into that manufacture, we will probably lose some of those customers. The pay-out does not look bad, but it's nothing to get exicted about if you assume that our present customers will look to someone else for their charge stock.

That business is in strong hands, and if we go into that manufacture, we will have to sell a more or less complete line of blacks—equip a rubber testing laboratory, and train a staff that is expert in this specialized field. I am going to recommend no action until we see a better picture.

President: Before we adjourn this luncheon, I would like to give our outside board members a chance to ask any questions or make any observations that may be on their minds. Major, was your point about B-B* going to Rubber Reserve answered? Did you have anything further to say on that matter?

Drake: As I understand your situation, you don't need the outlet; and synthetic rubber is apt to be a shrinking commodity just as channel black. They are going to produce rubber in the Far East or go back into the jungles to live, and I don't think they will do the latter very long.

President: Zac, what do you see in this postwar period from your position in the banking community that we ought to keep in mind?

Zacharias Greenback, outside director: Mr. Chairman, your financial report as well as the report of the production, refining, and marketing groups ought to make our stockholders more than satisfied that their investment in this company is a good one. The demand for fuel and power will have to grow as the standard of living rises and population increases. Your plans for more reserves, more refining and broader distribution will call for a lot of money yet I don't see how else we can keep our position; we must be prepared to take these risks with our own business. (pause)

I must confess that I am bothered about whether we are doing enough in this petrochemical fie!d. I read and hear about miracle this and miracle that and and I wonder sometimes whether we are overlooking some of these fantastic developments in these other lines. There must be some miracle men in the oil industry too.

What about atomic energy—we sell energy, "horse powers"; is that going to put a ceiling on the value of the crude reserves that we own? Are we putting too high a value on the reserves you are proposing to buy now?

President: That is a most important question, Zac. I have been thinking about that myself, but I always get back to the fact that the big boys are out after the same reserves—we think we've done well in meeting their competition. If we are wrong, so are a lot of others who have this same problem.

Judge, you have been remarkably quiet all day, would you like to give us your counsel?

Judge Bean, director: You went a whole year without any new Department of Justice or Trade Commission citations to face.

President: Do you think we can cut down on our legal staff?

Judge Bean: I wish I did. I wish I knew where the Federal Power Commission is leading us. The Supreme Court is hard to predict. But if Congress leaves the depletion allowance alone, we will get along.

President: Say, I heard that there is a move afoot to get Congress to give a faster write-off to manufacturers on all new capital investment. I'm in favor of it if they don't take it away from depletion allowance. It might be a good way of getting into petrochemicals. We'll have to keep that in mind.

I don't want to cut short on this meeting, but these visitors are here from Zeta Chemical Company. Jack, why don't you stay over; more than likely they have something to talk about that would concern the refining end.

Curtain

XUM

ACT II, Scene I

Cabot Standish, assistant to president: Now to show you in graphical form what I have been discussing, we have here a series of charts to contrast the fiscal performance and characteristics of the oil industry in relation to the chemical industry. The data concerning the oil industry are based on a financial analysis by the petroleum department of the Chase National Bank for 35 oil companies in this country. Twenty-one of these companies are among the 100 largest manufacturing companies in the Unietd States.

By contrast with the oil industry, fiscal data on the chemical industry has presented a major problem of selection, due to the fact that the areas of chemical manufacture have become so varied, especially during the past three decades. Twenty companies have been included in the composite** (Ed. note: identified in the footnote) whose activities embrace a weighted representation in the fields of rubber, plastics, coatings, artificial fibers, petrochemicals, soap, detergents, carbon black, nonferrous metals, alloys, and photographic supplies. Of the twenty companies, nine in 1953 were among the 100 largest manufacturing companies in the United States.

Before tracing the fiscal record during the past 10 years of the 35 oil companies and 20 chemical companies, I think you will be interested in some data published by the National City Bank of New York in which they estimated the per cent profit on sales and on net assets for the year 1953—an excess profit tax year—for industrial activities that we have chosen to composite in our 20 chemical companies. These are necessarily estimates because, as I have just pointed out, many companies are active in several different lines, and their annual reports do not disclose the origin of earnings. (Chart 1)

The remaining charts are based on the reported fiscal information of the specific companies previously identified. In Chart II we have plotted the growth in sales and invested capital.

Chart III traces the ratio of net income to total income.

Chart IV shows net income in relation to total invested capital of these same two groups.

To see how these industries have financed their growth, Chart V shows the distribution between the borrowed and total invested capital. Borrowed capital has been plotted in each case as a per cent of total invested capital.

You will note that we have compared the earnings after taxes of integrated oil companies and chemical companies, giving full effect in all cases to income from external sources, such as investments in domestic and foreign companies. We have done this deliberately because the money presumably is invested where, in the judgment of the officials, is—or was—most wise from the point of view of the stockholders. Especially I want to point out that these data do not compare refinery operations with chemical operations separate and apart from other activities of these companies. While this tends to cloud performance of a strictly chemical operation, it does give effect to the responsibility and choice that the several boards of directors have exercised in conducting the affairs of their respective companies. Moreover, that is the very heart of the problem that your board must face when selecting projects in which to invest your money.

One of the characteristics of the chemical industry is its many products —some are new and growing rapidly, others are staple in nature and are expanding with the population. It should not be a surprise to find that others are actually declining. Representative ex-

**Allied Chemical & Dye, American Cyanamid, American Viscose, Atlas Powder, Columbia Carbon, Commercial Solvents, Diamond Alkali, Dow, duPont, General Anilin and Film, Goodrich, Hercules Powder, Hooker, Koppers, Monsanto, Procter & Gamble, Air Reduction, Pennsylvania Salt, Union Carbide, Victor Chemical.

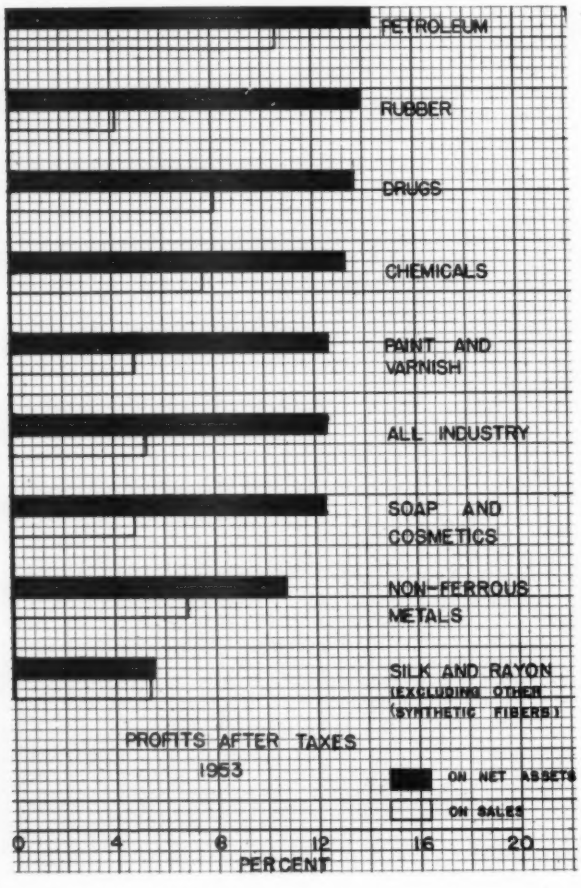


CHART I. Fiscal record of 35 oil companies and 20 chemical companies.

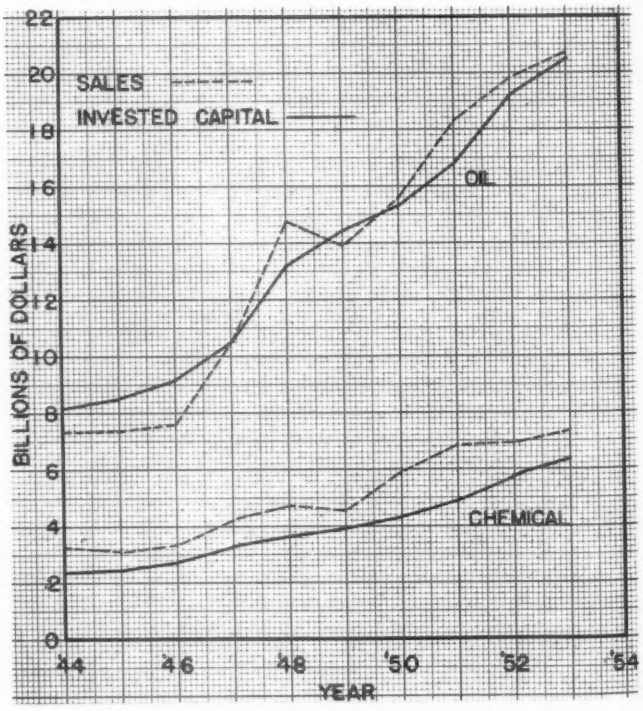
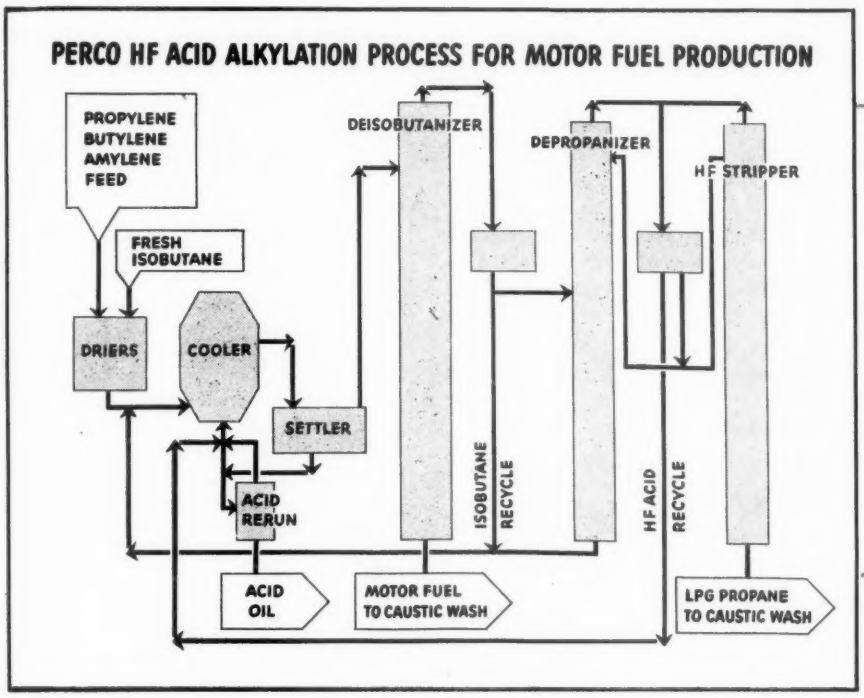


CHART II. Relationships between total sales income and invested capital for representative oil and chemical companies, and the growth of each.

PERCO HF ALKYLATION

the economical route to

HIGHER OCTANE MOTOR FUEL



Liquid feed, containing olefins and isobutane, is passed through driers and fed into a cooler along with liquid recycle hydrofluoric acid. Hydrocarbons and recycle acid then flow to the settler. The acid phase is recycled to the cooler. The hydrocarbon phase is fractionated to separate high octane motor fuel alkylate from recycle isobutane.

● On Christmas Day, 1942, Phillips began operating the world's first HF Alkylation unit. Phillips designed this plant from data developed in Phillips laboratories and pilot plants. Today, the original unit is still operating, with its original capacity increased from 1,750 to 12,000 barrels per day.

Now, Perco Division offers refiners a simple, streamlined and thoroughly proved HF Alkylation process that incorporates the many benefits of Phillips unmatched operating experience with this process.

Construction and operating expenses are low.

Perco HF Alkylation requires no more utilities and manpower than does an equivalent cat-poly unit. Yet yield, based on olefin content, is about 2½ times better for HF Alkylation compared with catalytic polymerization. ASTM distillation final end point is appreciably lower for HF Alkylate compared to cat-poly gasoline. Furthermore, TEL and normal butane blending values are particularly attractive with motor fuel alkylate.

HF Alkylation licensed by Perco includes rights under the patents of Universal Oil Products Company and thus confers full patent protection to the licensee. Consult today with Perco about the advantages of HF Alkylation for production of higher octane motor fuels.

PERCO *Division*

Phillips 66

PHILLIPS PETROLEUM COMPANY

BARTLESVILLE, OKLAHOMA

PERCO*

*A SERVICE MARK

amples are reproduced in Chart VI from the Survey of Current Business. Note, for example, that synthetic detergents are among the "fast growing" —and at the expense of soap, which is "declining." Lithophone and white lead are likewise "declining" and are undoubtedly being replaced by newer pigments such as titanium dioxide. We in the petroleum industry seldom experience these counter trends unless we go back to the days when gasoline was a by-product and kerosine for lamps was the important component of crude oil. Product mortality is relatively more important to the chemical industry than to ours. (Chart VI)

How important is the chemical industry as a customer of the oil industry hydrocarbons? The two principal classes of raw materials from a dollar value standpoint are:

I. Olefins: Ethylene, propylene, butylene. These originate in refining gas or are derived by cracking LPG.

II. Aromatics: Benzene, toluene, xylene, naphthalene. These materials are, or can be, made in a Cat reformer operation. Expressed in barrels per year the consumption of the chemical industry is shown in Chart VII.

All olefins are supplied by the oil industry. On the other hand, an important part of the aromatic hydrocarbons originate as a by-product of the coke industry. In Chart VIII the relative amount of aromatic hydrocarbons supplied by the oil industry is expressed percentage wise. Today there is no indication that the oil industry will be able to displace or undersell the coke oven production. You will note that the oil industry is prominent as a supplier of toluene and xylene, relatively minor in benzene and supplies no naphthalene.

I think you can conclude from the foregoing that:

(1) The chemical industry has not earned a disproportionately high return on its investment, and that the oil industry does not suffer by comparison,

(2) that in spite of its growth during the past few years it has not staggered or even strained the oil industry to supply the raw materials required, and

(3) considering the relatively small amount of hydrocarbon used, the chemical industry capital investment is large—which is another way of saying that the opportunities for effective integration of chemical manufacture into oil refining are highly selective or otherwise limited.

President: Thank you, Cabot.

This concludes our meeting but I hope the visiting stockholders, who in many cases have come long distances to be with us, will feel free to stay and

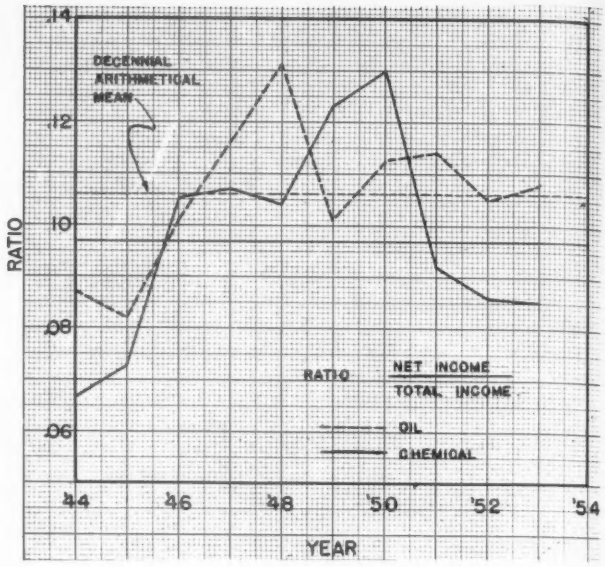


CHART III. Ratio of net income to total income (gross), for groups of representative oil and chemical companies.

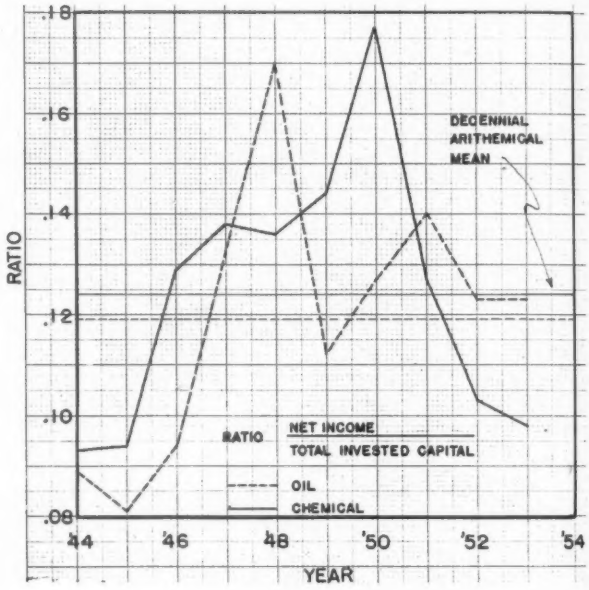


CHART IV. Comparison of the ratio of net income to total invested capital in the oil and the chemical industries.

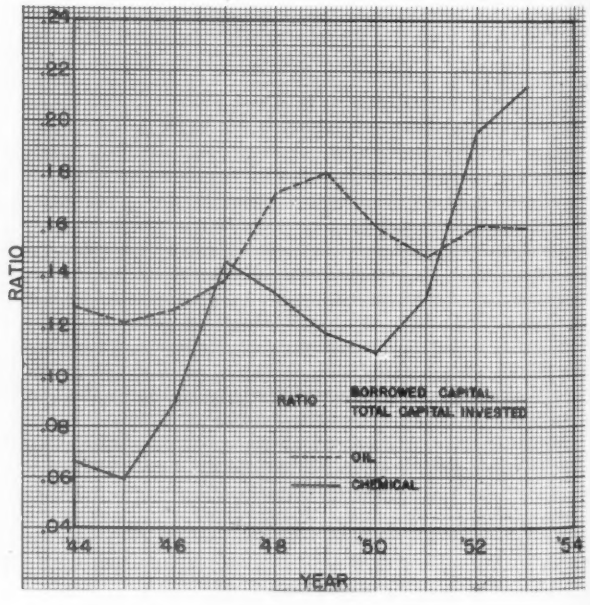


CHART V. Recent borrowing habits of the oil and chemical industries; these curves show the comparative ratio between borrowed capital and total capital invested in these industries.

DOW CORNING CORPORATION

Silicone News

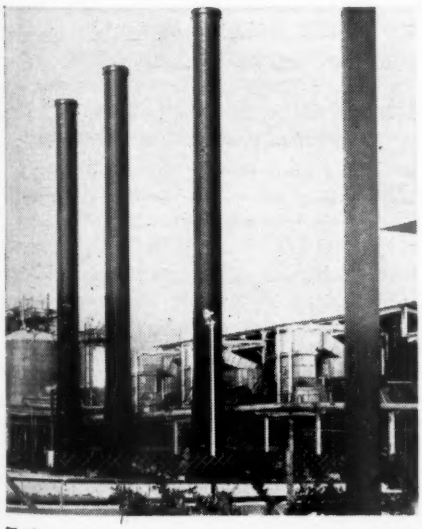
ABOUT PROTECTIVE COATINGS

Silicone Stack Paints Last Longer at 700 F

The Cit-Con Oil Refinery near Lake Charles, Louisiana, is one of the newest and largest fully integrated lubricating oil and paraffin wax plants. A joint enterprise of Cities Service and Continental Oil, the plant is finished in sparkling aluminum and gleaming black.

Soon after this modern refinery was completed, it became evident that even the most heat-resistant organic black finishes would not last from one annual unit shutdown to the next. The best of them developed rust stains in a few months.

Then in July 1952, when the steam boiler was down, the three 100 foot stacks in the unit were wire-brushed and a single coat of a silicone resin based black finish formulated by Allied Paint Company of Tulsa, Oklahoma was applied. The coating was allowed to air dry and cure in service. Later the petrochem heater stacks and all other stacks in the plant were refinished in the same manner.



Today, two years later, the black finish is as bright and glossy as ever, despite surface temperatures ranging from 350 to 700 F. Shutdown time has come and gone for most of the stacks with no refinishing required. The silicone paint has already paid for itself in reduced refinishing costs. *No. 1*

COST COMPARISON PROVES ECONOMY OF SILICONE PAINT

A recent article in *Oil and Gas Journal* cites detailed figures that prove silicone based paints are the most economical for applications involving high temperatures and/or corrosive atmospheres. Based on a study of maintenance costs at a large Southern gas transmission plant, the figures show that while the initial cost of silicone paints is about twice that of conventional protective coatings, silicone paints provide at least 3 time the service life.

After construction, new mufflers and stacks were cleaned, and then painted with 2 coats of silicone based aluminum paint. The cost per 100 square feet is shown in the box.

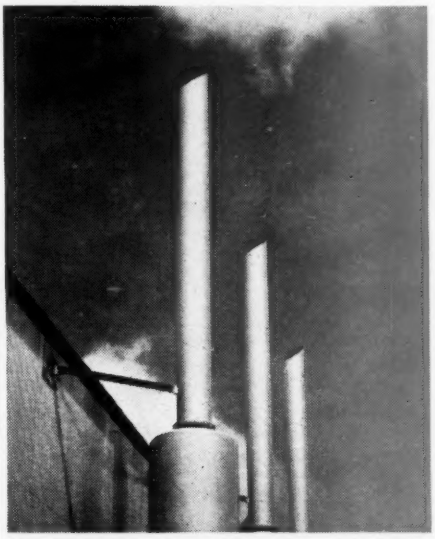
From past experience the company knew that the use of silicone paint would be economically sound if it remained effective only twice as long as the organic coatings used on similar installations. Although surface temperatures in this study ranged from 400 to 600 F, no additional maintenance was required for three years or 3 times as long.

Labor at $1.85 hour		
Sandblasting	$3.29	
Scaffolding	$2.46	
Painting	$3.29	$9.04
Materials		
Sand at $4.50 yd.	$2.00	
Paint, silicone aluminum at $17.50 gallon	$7.78	$9.78
Total Labor and Materials		$18.82

Costwise, that's about $.063 per square foot for a full year's protection. Compare that figure with your own annual costs for maintaining metal surfaces exposed to high temperatures and corrosive conditions. It's easy to understand why cost conscious maintenance men are changing to silicone based protective coatings. *No. 2*

New 1955 Reference Guide to Dow Corning silicone products gives in 8 pages a brief but comprehensive summary of the properties and applications for the silicone products that are most widely used. Products are indexed by type of application. With increasing importance placed on cost reduction and product improvement, a reference guide to these remarkably stable engineering materials becomes increasingly important to production and maintenance engineers. *No. 3*

New source of supply list names more than 60 formulators supplying durable protective coatings made with silicone vehicles. *No. 4*



SILICONE ALUMINUM PAINTS LAST 2½ YEARS at 950-1100 F

Outstanding success in the use of aluminum pigmented silicone paint on diesel exhaust stacks is reported by engineers at the San Patricio reduction plant of Reynolds Metals Company near Corpus Christi, Texas. To get a paint job that's still in excellent condition after 2½ years of service at 950-1100 F, the surface was sandblasted and a coating of grey primer was applied and baked by operating the Cooper-Bessemer engines for 24 hours. A top coating of silicone based aluminum paint was then applied and cured in service.

According to Plant Engineer R. C. Dill, "This paint job has created considerable interest among operators of diesel engines. It is, I believe, rather remarkable in view of the fact that many Gulf-coast companies consider 90 days to be an excellent life for organic paints on similar stacks." *No. 5*

DOW CORNING SILICONES

DOW CORNING CORPORATION
MIDLAND, MICHIGAN, DEPT. 8403

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City _____ ZONE ___ State _____

ATLANTA • CHICAGO • CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEW YORK • WASHINGTON, D. C. (Silver Spring, Md.)

Canada: Dow Corning Silicones Ltd., Toronto; **England:** Midland Silicones Ltd., London; **France:** St. Gobain, Paris

XUM

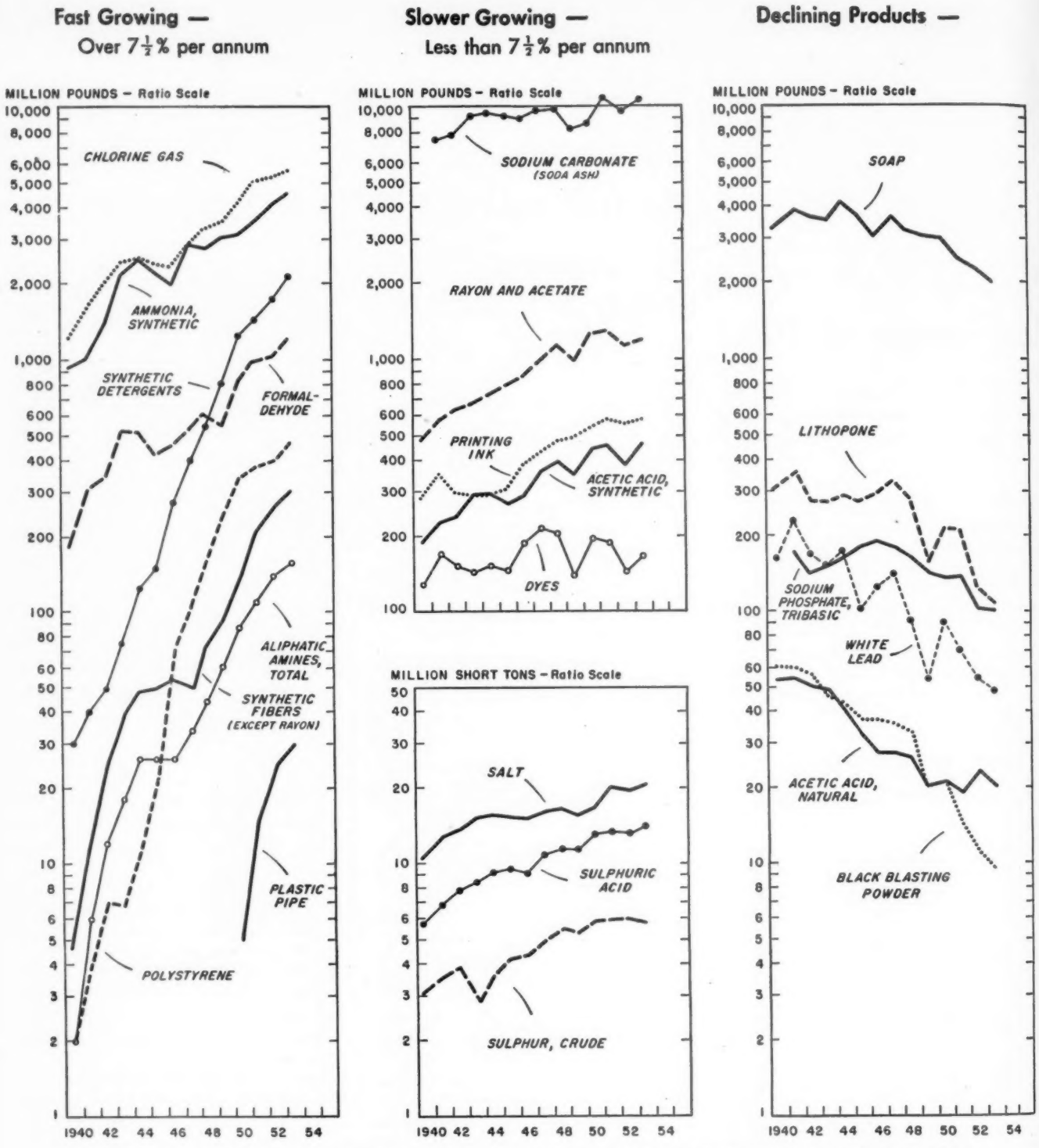


CHART VI. Production trends in chemical products (From "Survey of Current Business," U. S. D. C., Sept. 1954).

look over the refinery. You are welcome just as long as you want to stay. Thank you.

(*Curtain*)

ACT II, Scene II

Drake: Where does that Adam Chemical Company deal stand?

President: We decided to drop that. They make specialty finishes. They have a good earning record and a lot of chemists, but when you look at the volume of product moved—the specialized outlets for the products—Major, it's a prescription business. Sure they get five or ten times what we get for our industrial finishes, but we make these paints for our own use and sell some. We sell a carload or tank car when they sell five or ten gallons. I didn't like it. It's a good little business but they can have it.

It's not the kind of business we are accustomed to be in. They buy almost everything they use—mix it up in a few batch kettles with a bunch of men running around them. There were more chemists and doctors running around there per square foot than should be crowded into a whole county. They sure have chemists.

Kracker: That's what gave 'em the idea to call it a chemical company.

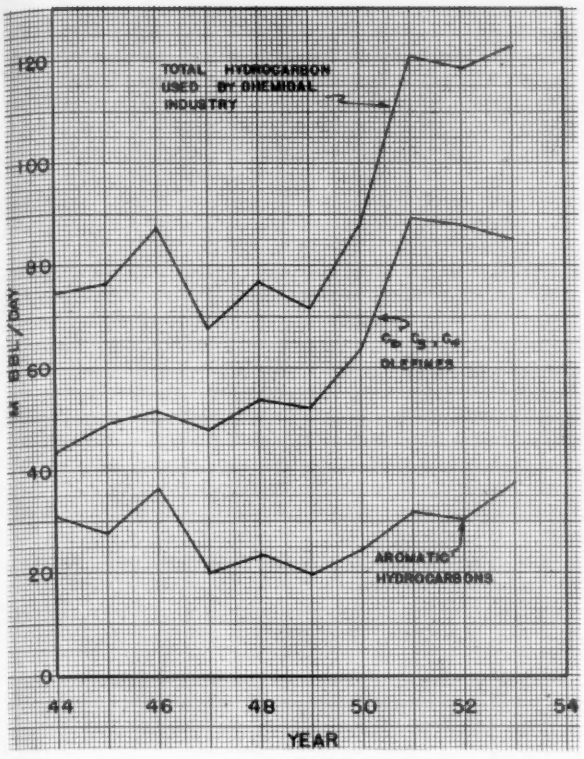


CHART VII. Total consumption of hydrocarbons by the chemical industry during the last ten years.

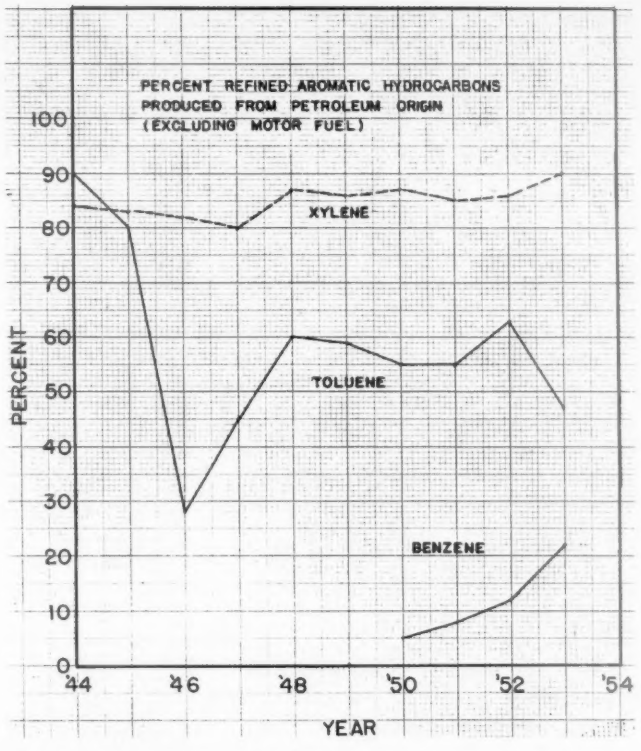


CHART VIII. Percentages of total refined aromatic hydrocarbons produced by the petroleum refining industry (excluding that used in motor fuels).

President: Now that Universe Chemical Company—that's different, but it's a batch proposition too. I mentioned Universe at the last board meeting.

They don't have as many chemists as they have at Adam, would you say Jack? At any rate I didn't see any white jackets running around there. They have been in business about 12 or 15 years—started just before the war. They need money. They have two lines of products, one I guess is making the money the other is losing or just breaking even and they have to expand to get their costs down to build a larger business. Oh yes, one of the important chemicals they buy costs them a lot more that it should and they have a process for making it that they are ready to put in. They need money.

The old line is a cement or adhesive that made money during the war and had been going reasonably well into peace time uses—wouldn't you say, Jack—anyway, they didn't say much about it. There weren't many people in that plant. The plant seemed to be running and the few people we saw were just sitting or standing around.

But this other operation in the other plant; there were fumes! The men all had masks on—everybody was running around but the plant was more or less standing still. They showed us some of the product. You can make light, spongy, mattress-like blocks. They expect it will replace a lot of cushion and mattress material. I was glad when I got out of there. Jack, what do you think about that show?

Kracker: I'm sorry Doctor Derre, head of our research, is not here. I don't know Boss, they may have something there. It's not going to compete with the motor fuel or lube oil business. They don't use any of our products and they've probably got a lot of headaches ahead of them.

President: I had a headache when I left that plant. It was the fumes, you know.

Kracker: Doc seems to feel there is some potential there and some day it may really be big time. It's a new field.

Drake: You said they don't use any of our products?

Kracker: I would say, "no." But we didn't really get that far. We just had this chance to visit these people. Doc, knowing we are trying to get into the chemical field, urged that the Boss and I go over there and get acquainted. I am satisfied that nothing we make is a big factor in what they do.

Ed Dobbin, outside director: I thought you had to use refinery products or else you were not in the petrochemical business.

Kracker: Well, yes, and no. It might come from coal. Before the war all the benzol came from coal. It might come from gas. There are all sorts of chemicals and all sorts of ways of making them. A lot of them don't require anything out of a refinery or even anything made out of gas.

Drake: Some chemicals are made from corn. These antihistiminic chemicals are made with microbugs in some sort of corn liquor.

President: To answer your question, we're still looking—we are not passing up anything that will help us get into this field. This Doctor Derre looks like a pretty sharp chemical man to me and one of these days we're going to have what we're looking for.

He's not a miracle man, I don't want any of you to get that idea; you'll have to give him time. He's not spending much time on anything else except this one big job. Maybe he will come up with something. Boys it's like the time when we started to hire those Ph.D.'s in geophysics instead of more doodle bugs. Even so, we had a lot of dry holes—we are going to have some here —you've got to expect that.

Kracker: Boss, I'm going to loosen my collar. You know—we have two or three vacuum still installations and a solvent refining unit for lube stock, which are not what you would ordinarily call chemical operations, but, except for them, our whole refinery operation today is chemical. Reforming, catcracking, alklyation, polymerization, that's all chemical, even if we don't call it chemical. Furthermore, just in the last three years we have started to make sulfur from our waste hydrogen sulfide. The only reason we didn't go ahead with our own acid plant is that we didn't feel we could market our

spent acid. The new acid contract is low enough to keep us out and give us the full market price credit for all the sulfur we can produce. We are marketing benzene, toluene, and xylene in the new Cat reformer installation. That's all chemical. The boys are itching to use the byproduct hydrogen for ammonia —I'm not sold on this yet. We have upgraded our cat cracker bottoms so that we can blend off a good part and get premium prices for it from our oil-black customers and the synthetic rubber folks for making these oil-extended rubbers.

I could go on naming other operations we have put in during and since the war, which are either chemical operations or give us products that go to customers for uses other than furnace or motor fuel.

Upp: Jack, how much chemical did you say we are putting into our premium lube oil now?

Kracker: Now there's another case. Almost 10 per cent of our premium lube oil is chemical additive and we average nearly 4 per cent. Nearly half that additive used is made in our own plant.

This may surprise you: In 1953 we used a larger quantity of additives than the whole industry consumed in 1935, and I don't have to remind you that we are a small factor in relation to the total lube oil production in this country.

I could go on and on; why three years ago we switched our poly unit over to make C_3 tetramer for these chemical folks—and there is a question in my mind now since we have plenty of benzol, whether we should ease into that water-soluble synthetic detergent field ourselves—we are making the oil-soluble types now.

Boss, I'm going to stop. But it all makes me wonder how chemical you have to be, to be in the chemical business.

President: (after a pause) I've said it before: it seems to me that our stockholders don't know enough about our business. (shaking his head) They keep asking all these questions.

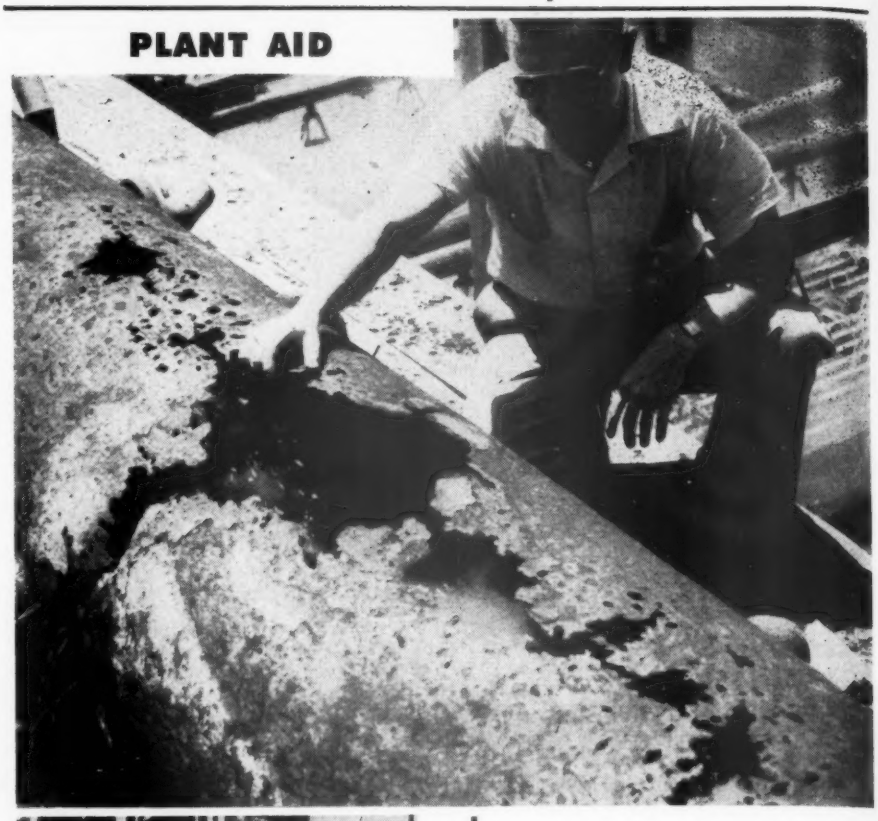
I don't like to cut short this meeting —we don't get together like this often enough. If any of you would like to stay and visit, feel free to do so. It was a good meeting.

(All start leaving the room while the president assembles loose paper and reports on the table. He looks up.)

President: Boys, I've got an idea! What would you say if we changed the name of the Master Petroleum and Refining Company to Master Petroleum and Chemical Company?

The End

PLANT AID



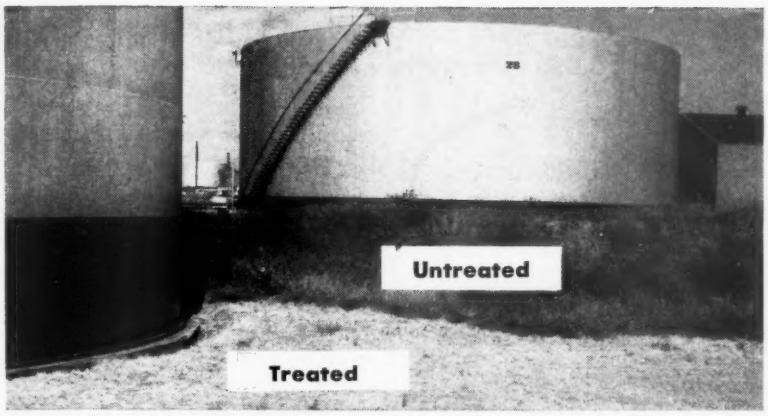
Resin Mends Eroded Water Header

With a 40-ft water header rusted completely through for most of its length, and the remainder paper-thin, Celanese Corporation mended it by covering with, first, two plies of glass cloth impregnated with a self-curing blend of Celanese MR-28C Resin, that covered the large holes completely. Then leaks were plugged and two additional plies of the same resin-saturated glass cloth were wrapped separately around the eroded pipe.

Job used 30 gal of resin; materials cost $137.88. Not having to remove the pipe or its many connections saved many man-hours that would be necessary of the whole section were replaced. As shown in the second photo, the laminated repair job over the completely rusted-through portion will bear the weight of a man standing on it. Long service without repairs is expected. If repairs are required, only more plies of impregnated glass cloth will be needed to do the job.

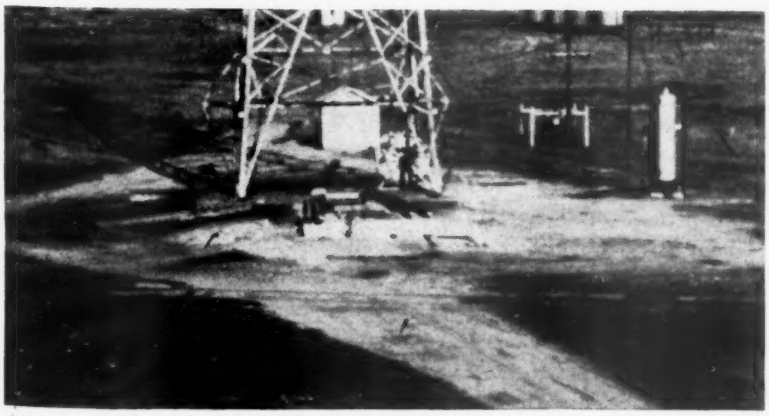
Weed and Brush Control lasts longer with Du Pont TELVAR® and AMMATE®

Weed Killers *Weed and Brush Killer*



Fire hazards are reduced around oil storages from thorough, long-term weed control with Du Pont "Telvar." "Telvar" is non-corrosive, won't harm application equipment.

Heavy weed growth was controlled with one application of "Telvar." "Telvar" keeps pipelines and key areas accessible, efficient to work around.



"Telvar" is ideal for weed control around derricks, pumps, storages. "Telvar" is easy to apply; extremely low in toxicity to humans and animals; non-flammable; and non-volatile.

One application of "Telvar" solves weed problems for a season or longer!

"Telvar" kills through the roots . . . prevents regrowth. Low dosages (20 to 80 lbs. per acre) make it cost little for the results you obtain. Low rates also mean less handling, less storage facilities. If you're looking for a way to cut maintenance costs to new low levels, include "Telvar" in your weed-control program. Available in two formulations: "Telvar" W; and "Telvar" DW, which is especially suited for light, sandy soils and in areas where annual rainfall is higher than 20 inches.

"Ammate" kills more kinds of brush and keeps it down longer than most weed and brush killers!

When the original spray job is well done, brush is kept under control with nothing more than an occasional spot spray later. You can rely on "Ammate" to do the job safely, even where your rights-of-way adjoin crop land, because "Ammate" is not volatile. There are no vapors to drift onto sensitive crops.

FREE ILLUSTRATED BOOKLETS describe how to control weeds and brush with Du Pont chemicals. For your copies, write to Du Pont, Grasselli Chemicals Dept., Rm. D 4032, Wilmington, Del. In Canada—Du Pont Company of Canada Limited, Box 660, Montreal.

TELVAR® AMMATE®

Weed Killers *Weed and Brush Killer*

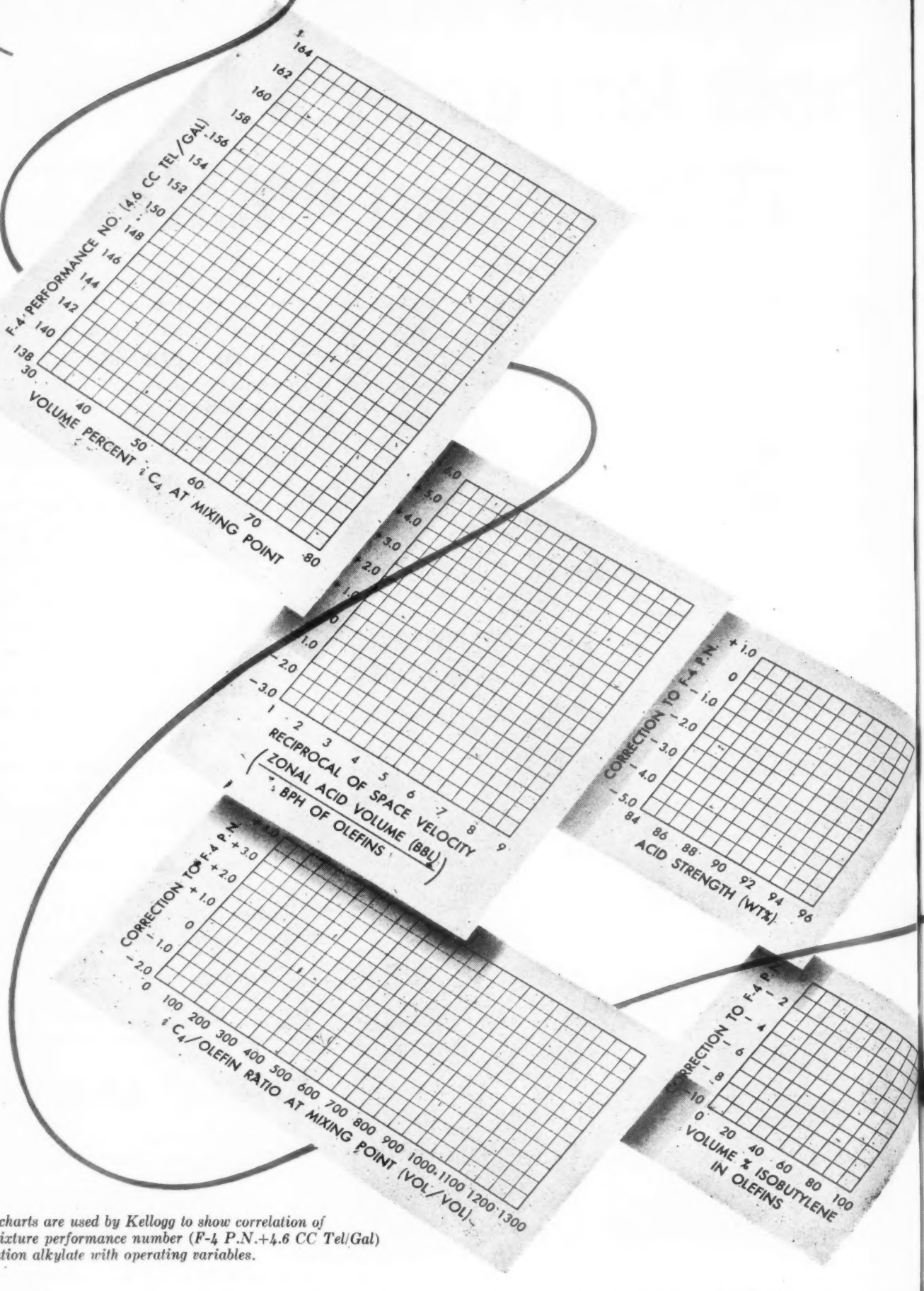
On all chemicals always follow directions for application. Where warning or caution statements on use of product are given, read them carefully.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

INSIDE TRACK IN THE OCTANE RACE...


F-4 PERFORMANCE NO. (4.6 CC TEL/GAL)
VOLUME PERCENT i C4 AT MIXING POINT
RECIPROCAL OF SPACE VELOCITY (ZONAL ACID VOLUME (BBL) / BPH OF OLEFINS)
CORRECTION TO F-4 P.N.
ACID STRENGTH (WT%)
i C4/OLEFIN RATIO AT MIXING POINT (VOL/VOL)
VOLUME % ISOBUTYLENE IN OLEFINS

These charts are used by Kellogg to show correlation of rich mixture performance number (F-4 P.N.+4.6 CC Tel/Gal) of aviation alkylate with operating variables.

Kellogg Alkylation

-INVESTMENT PAYOUT IN ONE YEAR!

A quick way to higher octane ratings at lowest operating and investment costs is sulfuric acid alkylation—utilizing Kellogg's unique cascade reactor and auto-refrigeration system.

Providing exceptionally high yields of superior alkylate, this Kellogg process sharply reduces the cost of the isobutane recycling equipment; maintains acid consumption at the lowest possible level; assures efficient mixing in reaction sections at low horsepower.

The accompanying co-ordinates demonstrate a few of the variables confronting the alkylate process engineer. The curves of these co-ordinates have been worked out through Kellogg research and experience, and the design results are available to refiners planning new alkylate capacity.

An example of what Kellogg alkylation can do in attaining premium results working with various blending components is provided by a recent study undertaken by Kellogg engineers of a proposed new 25,000 BPSD refinery on the Gulf Coast. Here, alkylation of total C_3 and C_4 olefins, assuming extraneous isobutane available at nominal price, results in the production of 15 volume percent on crude of high octane alkylate, with a payout on incremental investment over a base case of well under one year.

A comparable study of incremental alkylation not requiring extraneous isobutane, but compared with a base case incorporating non-selective catalytic polymerization, shows a payout of just over a year. Under these conditions alkylate production amounts to 6 volume percent on crude, and the combined alkylate plus catalytic polymer to slightly over 9 volume percent.

REFINERY PROCESS DIVISION, THE M. W. KELLOGG COMPANY, 225 BROADWAY, NEW YORK 7, N. Y.

In Canada: The Canadian Kellogg Company, Limited, Toronto. In Europe: Kellogg International Corporation, London

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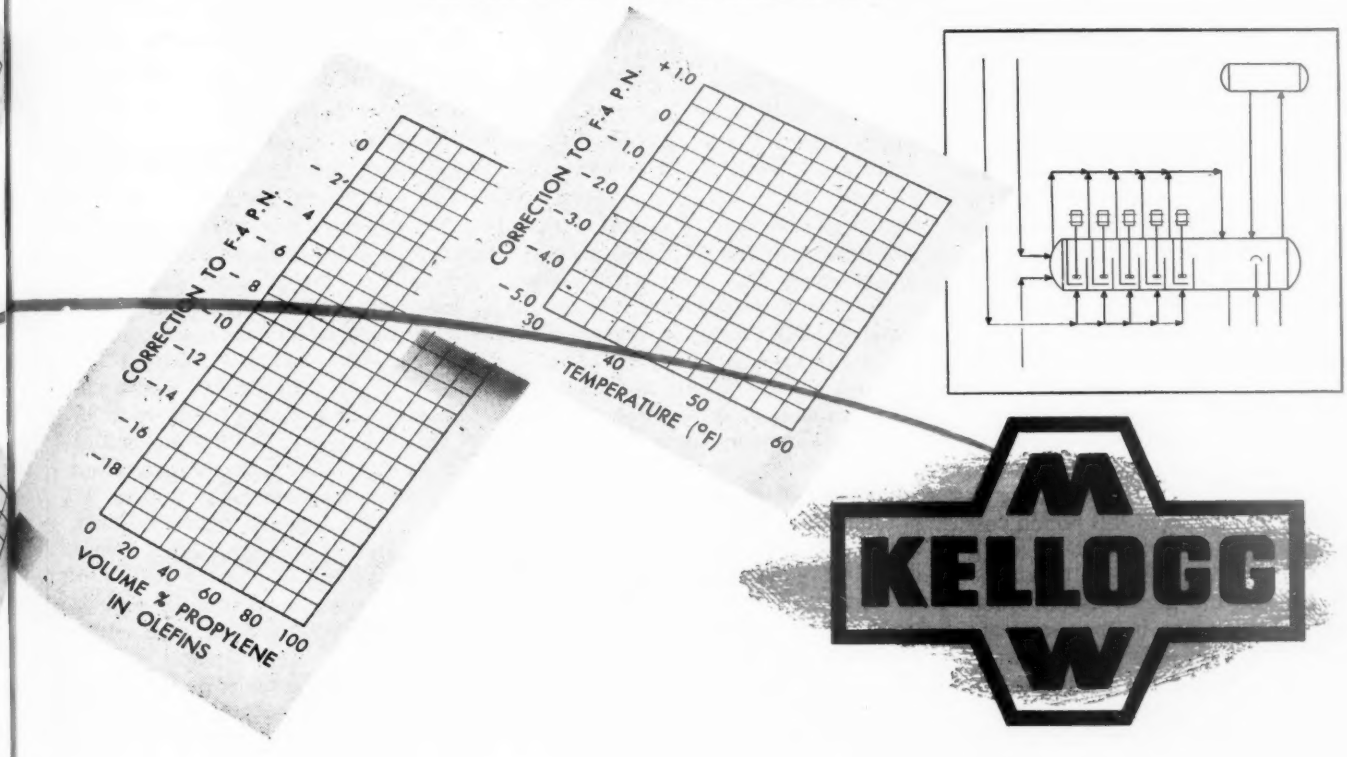

The "squeeze" created by demand for both large volume and high octane is expected to continue

Catalytic Processes Occupy Crucial Position

Vanderveer Voorhees*

PROBABLY no year since the beginning of catalytic conversion some 20 years ago, has witnessed such progress in the development and expansion of catalytic cracking and reforming as 1954. The year was perhaps most notable for showing the recognition by refiners of the crucial position of catalytic processes in meeting the demand for both large volume and high octane by the motoring public.

Never has the squeeze between volume and octane been so great and never has it been so clear that this pressure will continue. In '54, the average octane number, Research, was put up to 85.7 and 93.0 regular and premium grades, respectively, and a look at the accompanying chart will show which way octanes are headed. Although compression ratios of new cars took a breather, the 1955 models are all sharply up with the "low price" field running 7.4 and 7.6 and Buick at 7.5, 8.4, and 9.

The picture is hardly one to lull the refiner into a feeling of complacency, especially when constantly increasing demand prevents selection of special stocks and blends. Production of new cars in 1955 is estimated at 5.7 million, and registrations of cars, trucks, and buses is up to 58 million.

No less authority than Dr. D. P. Barnard, past president of SAE, has said the trend toward higher octane probably will continue, at least until premium grade reaches 100 Research, but the pace may slow down owing to the fact that octanes in this region cost about four times what they do at 70 to 72. Some have predicted 100 octane in 1961, but the higher compression engines coming out in the new cars promise to push this date forward rather than backward, even though the average car on the road will be satisfied with much less. Little help can be expected from addition of more lead, which is under fire from the cylinder deposit angle and lately from the suspicion that it may complicate the smog problem in congested areas. The recent DuPont survey showed an average lead tetraethyl content per gallon of 2.32 cc premium grade and 2.07 cc regular, not very much less, showing to what degree refiners are depending on catalytic cracking and reforming to meet the high octane levels of premium grades.

*Consulting chemical engineer.

New Developments in Catalytic Cracking and Reforming

The year 1954 saw many significant new developments. Standard Oil Development Company announced its "Model II" fluid catalyst reformer employing the pebble heater principle to supply heat required in the reactor. The catalyst is molybdena on alumina.

Both Standard of Indiana and Sinclair Refining have brought out reforming processes employing platinum catalysts. With the Platforming process of Universal Oil Products Company and the Catforming process of Atlantic Refining Company, this makes four processes using platinum. The Union Oil Company has nearly completed the first unit of its "Hyperforming" process employing a cobalt molybdate catalyst in a moving bed. Socony-Vacuum Oil Company announced its new Thermofor Catalytic Reforming process employing a chromia-alumina bead catalyst in moving beds. The first two units will go on stream early in 1955. Atlantic Refining Company built an ammonia plant to use the by-product hydrogen from its Point Breeze hydroforming operation and plans three more plants. Sun Oil Company also will build a 300 ton per day ammonia plant at Marcus Hook and a similar plant will be built in Hammond, Indiana, to use hydrogen from the Sinclair and Standard Oil (Indiana) refineries there.

In catalytic cracking there is a trend toward integration of the vessels in the fluid catalyst process as exemplified by M. W. Kellogg Company's "Orthoflow" process. The "Model B" has the regenerator above the reactor in a single, divided vessel. One of these units is designed for a throughput of 86,000 bbl per day charge, showing that the trend toward larger capacity units is continuing. The new "Model IV" fluid unit of Standard Oil Development Company is lower than its predecessors. The 20,000 bbl per day fluid catalyst cracking unit of Richfield Petroleum Company near Los Angeles went on stream with a steam generator obtaining heat by combustion of CO in the regenerator flue gas. This and a similar unit at Houston, Texas, are the first to recover heat from this source. At the same time, air pollution is reduced, an important consideration in Los Angeles and similar smog areas. American Cyanamid Company has put on the market a high alumina catalyst containing 25 per cent alumina, said to have higher performance stability.

EXCLUSIVE

Catalytic Reforming[1]

Most of the processes recycle hydrogen to prevent carbonizing the catalyst. Tail gas is used for this purpose and may be treated to remove H_2S, in which case desulfurization is an important feature of the process. Endothermic heat of reaction is usually supplied by reheating the stream between multiple catalyst beds. In the Union Oil Company "Hyperforming" process, hot hydrogen assists by recycling it to successive points in the moving bed catalyst stream. In fluid catalyst reforming, the catalyst recycle stream itself supplies the required heat of reaction.

At the end of 1954 there was available in the U. S. about 450,000 bbl per day of catalytic reforming capacity. Following are some of the high lights of the year:

"Thermofor Catalytic Reforming" (Socony-Vacuum Oil Company)—The features of this process are a low cat-

[1]Symposium on Reforming, *The Petroleum Engineer*, April, 1954, pp. C-13-37.

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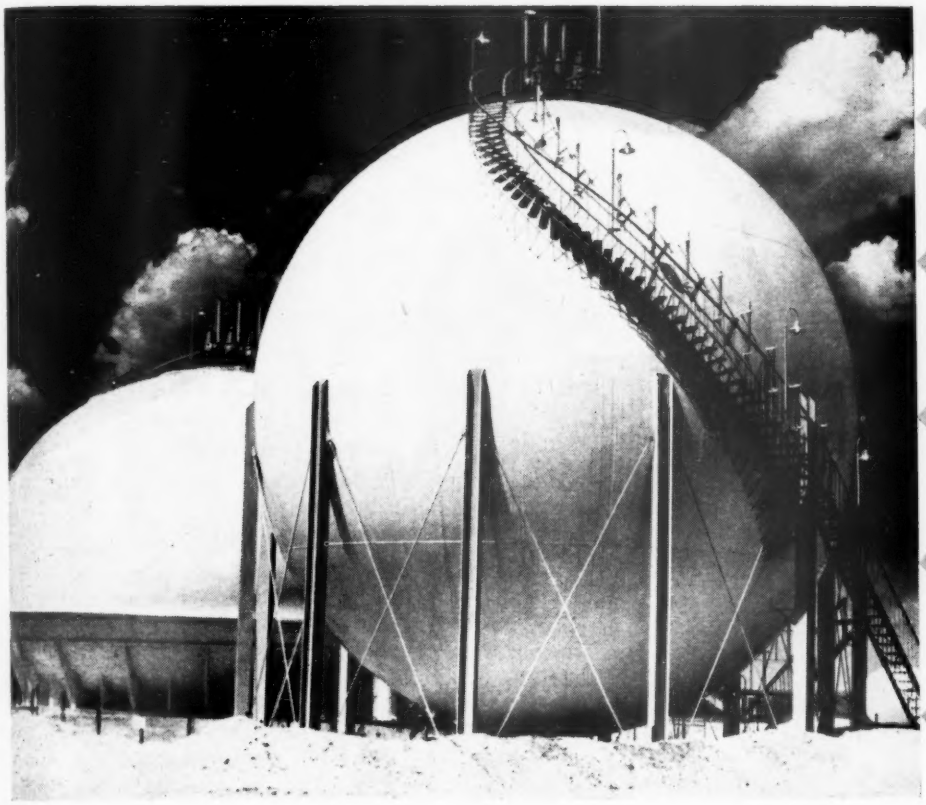

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alyst recycling rate in a moving bed using a mol ratio of hydrogen to feed of 3:1 at 100 to 200 psi and 950 F. A bucket elevator is used to convey the chromia-alumina bead catalyst to the regenerator, the amount of catalyst recycle being too little to require an air lift. Two 19,000 bbl per stream day units will go on stream about March, 1955, one at Torrance, California, for General Petroleum Company, and one at Beaumont, Texas, for Magnolia Petroleum Company.

Sinclair-Baker—The catalyst in this process contains platinum and is made by Baker specifically for reforming. Three fixed bed reactors are employed in series at 200-750 psi and 825-950 F with a molal hydrogen recycle ratio of 3-10. Runs of 40-200 bbl per lb of catalyst are obtained before renewal of catalyst. One 16,000 bbl per day unit has gone on stream at Marcus Hook and another identical unit will go into operation at East Chicago next month. Another unit of larger capacity is in the planning stage.

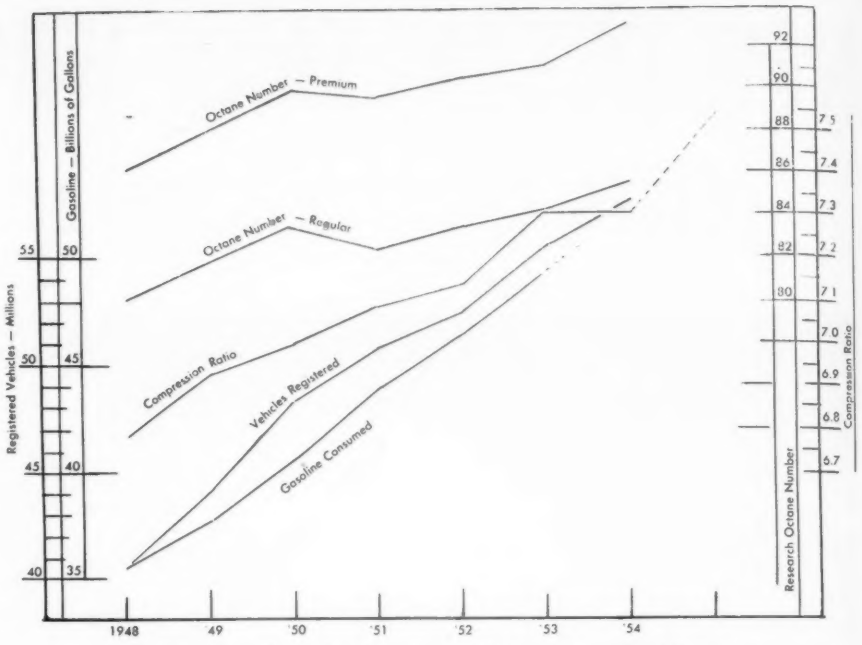
"Ultraforming" (Standard Oil Company of Indiana)—This process also employs a platinum catalyst, which is made by the American Cyanamid Company. The catalyst beds are regenerated in situ when required at intervals of a week to several months. Operating pressure is about 200-300 psi at 900-950 F with hydrogen recycle. Two units went into operation last year at El Dorado, Arkansas, 6200 bbl per stream day, and Casper, Wyoming, 3700 bbl per stream day. Seven additional units are in construction, viz:

Wood River, Illinois	9,000 B/SD
Sugar Creek, Missouri	14,000 B/SD
Texas City, Texas	21,000 B/SD
St. Paul (Great Northern)	5,300 B/SD
Baytown, Texas (Humble)	30,000 B/SD
Baytown, Texas (Humble)	20,000 B/SD
Montreal (Petrofina)	3,600 B/SD
Units are also in design for	
Utah Oil Company	5,000 B/SD
Leonard Refining, Inc., Alma, Michigan	2,400 B/SD

The total when completed will be 113,900 bbl per stream day.

"Catforming" (Atlantic Refining Company)—This process also features a platinum activated catalyst of the silica-alumina type. Long operating cycles are obtained with yields of 35 to 100 bbl per lb of catalyst. Regeneration *in situ* with steam-air mixture restores the activity. Recycle hydrogen is scrubbed with an amine to remove H_2S. Recycle rate, 8000 cu ft per bbl; pressure, 300-700 psi; temperature, 850-950 F.

Fourteen units are in operation with a total capacity of 44,900 bbl per day, the latest unit coming on stream at Port Arthur, Texas, with a capacity of 8000 bbl per day. Four more units are under construction in Canada, two for the British-American Oil Company at Montreal, (13,000 bbl per day) and Calgary (2000 bbl per day) and two for the Husky Oil and Refining Company at Moose Jaw and Fort Williams (1000 bbl per day each).



These curves show the sharp upward trend in automobile-motor fuel in recent years

"Fluid Hydroforming" (Standard Oil Development Company)—Operating at 200 and 900 F, this process is unique in employing a fluidized solid catalyst that is regenerated in the cycle at 1100 F. The catalyst serves to supply heat for the reforming reaction in the Model I design, while the Model II design will employ a separate cycle of heated pebbles or shot for this purpose. All the units now operating, however, are of the Model I design. Tail gas is recycled at the rate of 2000-4000 cu ft per bbl. The catalyst is molybdenum on alumina.

The second unit, 12,750 bbl per stream day, went on stream late in 1954 at East Chicago for Cities Service Company, the first having gone into operation at Destrehan, Louisiana, in 1953 (2000 bbl per stream day). Three more units are nearly completed and will go on stream early in 1955, viz:

Baton Rouge (Esso Standard)	28,000 B/SD
Lake Charles, Louisiana (Cities Service)	17,250 B/SD
Whiting, Indiana Standard Indiana)	30,000 B/SD

Total, 90,000 bbl per stream day. An additional 60,000 bbl per stream day capacity is in production and on contract in foreign countries.

"Houdriforming" (Houdry Process Company)—This process features three fixed bed reactors in series with reheating between. Mol ratio of recycle hydrogen to feed is about 4-10; pressure, 250-600 psi; temperature, 875-950 F. Three units have gone into operation, one at Robinson, Illinois, (Ohio Oil Company, 8330 bbl per stream day), one at Marcus Hook (Sun Oil Company, 1500 bbl per stream day) and one at Sarnia, Ontario, (Sun Oil Company, 3000 bbl per stream day). Seven more units are under construction with a combined capacity of 50,000 bbl per stream day.

"Cycloversion" (Phillips Petroleum Company)—The applications of this well-known process are continuing to expand. In 1954, the total capacity exceeded 100,000 bbl per stream day with 33 units in operation ranging in capacity from 300 to 18,000 bbl per day each. Additional units are under construction with capacity of 29,000 bbl per day.

The catalyst is bauxite arranged in fixed beds and alternately regenerated at throughputs of 5000 to 20,000 bbl per ton. No hydrogen is recycled, but steam is charged with the feed. Pressure is 50 psi, temperature 875-975 F. Heavy naphtha or even light gas oil can be charged economically and sulfur is removed. Octane number increase is intermediate.

"Hyperforming" (Union Oil Company)[2]—The catalyst is a cobalt molybdate pellet, which is recycled through a downwardly moving bed and elevated in dense fluid phase or "mass flow." The catalyst is not sensitive to

[2]Paper by Clyde Berg, API Meeting, Houston, May, 1954, Division of Refining.

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heavy ends in the feed stock, thus simplifying feed preparation. The product has an exceptionally uniform octane level throughout the boiling range. A lock hopper is employed in the catalyst recycle line and regeneration takes place in the line. Hot hydrogen is recycled to spaced points in the reactor column. Pressure is 400 psi; temperature 800-900 F.

The first unit of 1100 bbl per day will go on stream early in 1955 at the Calstate Refining Company, Signal Hill, California. It will process a mixture of straight run and thermally cracked, high sulfur naphtha.

"Platforming" (Universal Oil Products Company)—This is the original catalytic reforming process using platinum activated catalyst; recycles hydrogen at 200-700 psi. Some 40 units are in operation. The following units went on stream in 1954:

Phillips Petr. Co., Sweeny, Texas	16,000 B/D
Quaker State, 3 units	3,200 B/D
Republic Oil & Ref., Texas City	5,500 B/D
Shell Oil Co., Martinez	4,500 B/D
Shell Oil Co., Wood River	16,000 B/D
Skelly Pet. Co., El Dorado	7,500 B/D
Standard Oil Co. of Ohio, Lima	12,000 B/D
Sunray Oil Co., Duncan, Oklahoma	5,000 B/D
Taylor Oil & Gas Co.	5,000 B/D
Texas Co., Westville, N.Y.	10,000 B/D
Union Oil Company, Oleum	14,500 B/D
Total	99,200

Gulf Oil Company will bring on stream in 1955 four units with combined capacity of 65,000 bbl per day, one unit having a throughput of 29,000 bbl per day total feed, the largest of its kind.

Catalytic Cracking

The demand for high octane gasoline has spurred the construction of more and more catalytic cracking capacity in every field of refining. To meet this demand refiners are cashing in on the extensive research programs they have supported for the last 20 years, which have provided the know-how to meet the present situation. During 1954 there went on stream in the U. S. and Canada, 19 new units with a total feed capacity of 469,500 bbl per day. Sixteen of these units were of the fluid catalyst type with combined capacity of 416,500 bbl per day, the others being of the moving bed type. Under construction are seven fluid units to process 94,500 bbl per day and seven units of the moving bed type to process 65,950 bbl per day. At the end of 1954 there was in the U. S. a total catalytic cracking capacity of about 3.3 million barrels per day, total feed basis, of which 2.3 million barrels was fluid catalyst capacity. A concise technical review of the leading processes was presented in a symposium in *The Petroleum Engineer* in April, 1954, p. C-86 to C-100.

Relative to the installed capacity, the moving bed processes represented by the Airlift TCC and the Houdriflow processes are showing a greater expansion than the Fluid Catalyst processes. During the year, four TCC units went on stream with a combined capacity of 50,500 bbl per stream day and two units are scheduled for 1955 with a capacity of 37,000 bbl per stream day. At the end of 1955 there will be 26 Airlift TCC units in operation in the U. S. with combined capacity of 387,000 bbl per stream day and an additional capacity in other countries of 215,500 bbl per stream day.

Fifteen Houdriflow units are in operation with a combined capacity of 165,500 bbl per day and additional units are under construction for Sun Oil Company at Toledo (27,000 bbl per day) and Petrofina Ltd., Montreal (16,000 bbl per day).

M. W. Kellogg Company has brought out its "Model B" "Orthoflow" unit having the regenerator over the reactor. Operating conditions are:

Reactor pressure	14-16 psi
Reactor temperature	885-950 F
Regenerator pressure	8-10 psi
Regenerator temperature	1050-1100 F
Cat./oil ratio	8-12
Space velocity	1-3 W/H/W

One unit has been designed for 86,000 bbl per day charge, which exceeds by a considerable margin any cracking unit yet built. The construction is simplified by using a single, divided vessel for both regenerator and reactor with appropriate channels for catalyst flow. With the regenerator above the reactor, lower regenerator pressure is obtained with resulting saving in air compression costs. Cone plug valves to control catalyst recycle are conveniently controlled from outside the reactor and eliminate trouble from erosion.

In the UOP fluid catalyst process the regenerator is beneath the reactor with outside catalyst stripper. Advantages are claimed for higher regenerator in reduced catalyst inventory and smaller equipment, which are believed to more than offset the increased cost of air compression. Indications are that this may be true in smaller capacity units but not in large units of 25,000 bbl per day or more. No one yet has been able to solve the erosion problem so that the regenerator flue gas can be passed through a turbine to recover the power it represents in escaping to the atmosphere. More than 60 UOP units are in operation in the U. S. and abroad with a combined capacity of about 400,000 bbl per day.

The utilization of waste heat and fuel in the regenerator spent gas for making steam is a new development of the Sinclair Refining Company and is operating successfully in two fluid catalyst units at Houston, Texas, and at Los Angeles, California (Richfield Petroleum Company).[3] Sufficient air and fuel are added to the regenerator flue gas to heat it to 1400 F in a steam boiler, producing, at Houston, 330,000 lb steam per hour at 700 psig. Additional steam is produced from wall coils located in the regenerator to control the temperature of the catalyst and permit higher rates of regeneration. Phenomenal rates of heat transfer are obtained in these coils, about five to seven times those obtained with hot gas instead of fluidized catalyst. In addition to the recovery of valuable heat, combustion of regenerator flue gas insures that no hydrocarbons will be discharged to the atmosphere to add to pollution causing smog conditions in congested areas.

[3]Campbell and Pennels, ASME New York Meeting; Paper No. 54-A-20, Nov. 28, 1954.

United States and foreign catalytic cracking, reforming units as of January 1, 1955, by states

Company	Location	Capacity B/SD	Type	Status
ARKANSAS				
Lion Oil Co.	El Dorado	10,000	Fluid Cat.	Operating
Lion Oil Co.	El Dorado	6,500	TCC	Operating
Pan-Am Southern Corp.	El Dorado	6,200	Ultraformer	Operating
Pan-Am Southern Corp.	El Dorado	18,000[2]	Fluid Cat.	Operating
Pan-Am Southern Corp.	El Dorado	17,000[2]	Fluid	Operating
CALIFORNIA				
Calstate Ref. Co.	Signal Hill	1,100	Hyperformer	Building
Douglas Oil Co.	Bakersfield	2,500	Catformer	Operating
General Pet. Corp.	Torrance	19,000	TCR	Building
General Pet. Corp.	Torrance	52,000	TCC	Operating
Hancock Oil Co.	Long Beach	40[1]	TCC	Building
Hancock Oil Co.	Long Beach	2,500	Cat reformer	Planned
Mohawk Pet. Co.	Bakersfield	2,500	Catformer	Operating
Mohawk Pet. Co.	Bakersfield	1,000	Platformer	Building
Richfield Oil Co.	Watson	35,000	Fluid	Operating
Richfield Oil Co.	Watson	25,000	TCC	Operating
Rothschild Oil Co.	Santa Fe Springs	1,200	Platformer	Building
Rothschild Oil Co.	Santa Fe Springs	6,000	Platformer	Building
Shell Oil Co.	Martinez	5,500	Platformer	Building
Shell Oil Co.	Wilmington	4,000	Platformer	Building
Shell Oil Co.	Wilmington	25,000	Fluid	Building
Standard Oil Co.	El Segundo	11,000	Platformer	Building
Standard Oil Co.	El Segundo	20,000	Platformer	Building
Standard Oil Co.	Richmond	20,000	Platformer	Building
Standard Oil Co.	El Segundo	40,000	Fluid	Operating

Company	Location	Capacity B/SD	Type	Status
Standard Oil Co.	Richmond	35,000	TCC	
Standard Oil Co.	Richmond	15,000	Fl. Hydroforming	Operating
The Texas Co.	Wilmington	10,000	Platformer	Building
The Texas Co.	Wilmington	20,000	Fluid	Operating
Tide Water Assoc. Oil Co.	Avon	10,000	Platformer	Building
Tide Water Assoc. Oil Co.	Avon	30,000	Fluid	Operating
Tide Water Terminals Co.	Pinale	9,000	Fluid	Operating
Union Oil Co.	Oleum	15,000	Platformer	Operating
Union Oil Co.	Los Angles	18,000	TCC	Operating
Union Oil Co.	Los Angles	30,000	Fluid	Operating
Wilshire Oil Co.	Norwalk	6,000	Fluid	Operating
COLORADO				
Bay Pet. Corp.	Denver	3,500	Fluid	Operating
Continental Oil Co.	Denver	3,300	TCC	Operating
ILLINOIS				
Advance Ref. Co.	Centralia	650	Cycloversion	Operating
Clark Ref. Co.	Blue Island	5,000	Houdriflow	Operating
Clark Ref. Co.	Blue Island	5,500	Platformer	Operating
Glove Oil and Ref. Co.	Lemont	12,000	Fluid	Operating
Illinois Farm Supply Co.	Pana	600	Platformer	Operating
Ohio Oil Company	Robinson	8,330	Houdriformer	Operating
Ohio Oil Company	Robinson	18,500	Fluid	Operating
Pana Refining Co.	Pana	750	Platformer	Operating
Shell Oil Company	Wood River	4,500	Platformer	Operating
Shell Oil Company	Wood River	55,000	Fluid	Operating
Shell Oil Company	Wood River	15,000	Platformer	Operating
Sinclair Refining Co.	Hartford	6,000	Cycloversion	Operating
Sinclair Refining Co.	Hartford	11,000	Fluid	Operating
Socony-Vacuum Oil Co.	East St. Louis	75[1]	TCC	Operating
Standard Oil Co. (Ind.)	Wood River	9,000	Ultraformer	Operating
Standard Oil Co. (Ind.)	Wood River	16,000	Fluid	Operating
The Texas Company	Lawrenceville	12,000	Platformer	Building
The Texas Company	Lawrenceville	30,000	Fluid	Operating
The Texas Company	Lockport	11,000	Platformer	Building
The Texas Company	Lockport	25,000	Fluid	Building
INDIANA				
Cities Service (Del.)	East Chicago	21,000	Fl. Hydroformer	Operating
Indiana Farm Corp. Ass'n. Inc.	Mount Vernon	3,750	Fluid	Operating
R. J. Oil & Refining Co.	Princeton	750	Platformer	Operating
Rock Island Ref. Corp.	Rock Island	6,500	Fluid	Operating
Rock Island Ref. Corp.	Indianapolis	1,500	Platformer	Operating
Sinclair Refining Co.	East Chicago	16,000	Sinclair-Baker	Building
Sinclair Refining Co.	East Chicago	34,000	Fluid	Operating
Socony-Vacuum Oil Co.	East Chicago	75[1]	TCC	Operating
Standard Oil Co. (Ind.)	Whiting	14,000	Hydroformer	Operating
Standard Oil Co. (Ind.)	Whiting	30,000	Ultraformer	Operating
Standard Oil Co. (Ind.)	Whiting	60,000	Fluid	Operating
KANSAS				
Anderson Prichard Oil Corp.	Arkansas City	5,500	Fluid	Operating
Anderson Prichard Oil Corp.	Arkansas City	4,000	Cycloversion	Operating
Cooperative Ref. Ass'n.	Coffeyville	6,500	Fluid	Operating
Cooperative Ref. Ass'n.	Phillipsburg	4,000	Fluid	Operating
Derby Oil Company	Wichita	45[1]	TCC	Operating
Derby Oil Company	Wichita	—	Platformer	Building
El Dorado Refining Co.	El Dorado	5,400	Fluid	Operating
Nat'l. Coop. Ref. Ass'n.	McPherson	11,000	Fluid	Operating
Phillips Petroleum Co.	Kansas City	30,000	Fluid	Operating
Shallow Water Ref. Co.	Garden City	1,500	Cycloversion	Operating
Skelly Oil Company	El Dorado	7,500	Platformer	Operating
Skelly Oil Company	El Dorado	16,000	Fluid	Operating
Socony-Vacuum Oil Co.	Augusta	75[1]	TCC	Operating
Socony-Vacuum Oil Co.	Augusta	3,000	Sinclair-Baker	Operating
Standard Oil Co. (Ind.)	Neodesha	9,300	Fluid	Operating
Vickers Petroleum Co.	Potwin	33[1]	TCC	Operating
KENTUCKY				
Ashland Oil and Ref. Co.	Catlettsburg	6,000	Houdriformer	Building
Ashland Oil and Ref. Co.	Catlettsburg	25,000	Fluid	Operating
Louisville Refining Co.	Louisville	3,300	Fluid	Operating
Somerset Refinery	Somerset	500	Cycloversion	Operating
LOUISIANA				
Atlas Processing Co.	Shreveport	5,000	Platformer	Operating
Bay Petroleum Corp.	Chalmette	7,500	Fluid	Operating
Canal Refining Co.	Church Point	750	Catformer	Operating
Cities Service Ref. Co.	Lake Charles	77,000	Fluid	Operating
Continental Oil Co.	Lake Charles	75[1]	TCC	Operating
Continental Oil Co.	Lake Charles	60[1]	TCC	Operating
Esso Standard Oil Co.	Baton Rouge	144,000[4]	Fluid	Operating
Esso Standard Oil Co.	Baton Rouge	20,000	Fl. Hydroformer	Building
Ingram Oil and Ref. Co.	Meraux	3,000	Fluid	Operating
Pan-Am Southern Corp.	Destrehan	15,000	Fluid	Operating
Pan-Am Southern Corp.	Destrehan	2,000	Fl. Hydroformer	Operating
Shell Oil Company	Norco	72,000	Fluid	Operating
MASSACHUSETTS				
Esso Standard	Everett	18,600	Fluid	Operating
MARYLAND				
Esso Standard	Baltimore	3,000	Hydroformer (Fixed bed)	Building
Esso Standard	Baltimore	36,000	Fluid	Operating
MICHIGAN				
Aurora Gasoline Co.	Detroit	4,500	Platformer	Operating
Aurora Gasoline Co.	Detroit	12,000	Fluid	Operating
Aurora Gasoline Co.	Elsie	1,500	Platformer	Operating
Aurora Gasoline Co.	Muskegon	2,400	Platformer	Operating
Bay Refining Corp.	Bay City	33[1]	TCC	Operating
Bay Refining Corp.	Saginaw	6,000	TCC	Operating
Lakeside Refining Co.	Kalamazoo	1,000	Cycloversion	Operating
Leonard Refineries Inc.	Alma	7,500	TCC	Operating
Mid-West Refineries Inc.	Alma	2,000	Platformer	Operating
Naph-Sol Refining Co.	Muskegon	1,000	Platformer	Building
Old Dutch Refining Co.	Muskegon	2,500	Platformer	Operating
Petroleum Specialties Inc.	Flat Rock	1,000		
Roosevelt Oil & Ref. Co.	Mt. Pleasant	3,000	Cycloversion	Operating
Roosevelt Oil & Ref. Co.	Mt. Pleasant	2,000	Platformer	Operating
Socony-Vacuum Oil Co.	Trenton	75[1]	TCC	Operating
MINNESOTA				
Great Northern Oil Corp.	St. Paul	5,300	Ultraformer	Building
Great Northern Oil Corp.	St. Paul	100[1]	TCC	Building
International Refs. Inc.	Wrenshall	5,000	Fluid	Operating
Northwestern Ref. Co.	St. Paul	5,000	Fluid	Operating
MISSOURI				
Standard Oil Co. (Ind.)	Sugar Creek	32,000	Fluid	Operating
Standard Oil Co. (Ind.)	Sugar Creek	14,000	Ultraformer	Building
MONTANA				
Carter Oil Company	Billings	15,000	Fluid	Operating
Continental Oil Co.	Billings	3,750	Fluid	Operating
Farmers' Union Central Exchange	Laurel	6,000	Fluid	Operating
Union Oil Co. of Calif.	Cut Bank	600	Catformer	Operating
NEW MEXICO				
Famariss Oil & Ref. Co.	Hobbs	600	Platformer	Building
Malco Refineries, Inc.	Prewitt	750	Catformer	Operating
McNutt Oil & Ref. Co.	Brickland	650	Platformer	Operating
New Mexico Asphalt & Refining Co.	Artesia	33[1]	TCC	Operating
NEW JERSEY				
California Oil Company	Barber	25,000[2]	Houdriflow	Operating
California Oil Company	Barber	10,000	Platformer	Operating
Esso Standard Oil Co.	Rahway	14,000	Fluid	Operating
Esso Standard Oil Co.	Linden	98,000	Fluid	Operating
Socony-Vacuum Oil Co.	Paulsboro	75[1]	TCC	Operating
The Texas Company	Westville	30,000	Fluid	Operating
The Texas Company	Westville	12,000	Platformer	Operating
Tide Water Assoc. Oil Co.	Bayonne	12,000	TCC	Operating
Tide Water Assoc. Oil Co.	Bayonne	17,500	Hydroformer	Operating
NEW YORK				
Frontier Oil & Ref. Corp.	Buffalo	10,000	Fluid	Operating
Socony-Vacuum Oil Co.	Brooklyn	75[1]	TCC	Operating
Socony-Vacuum Oil Co.	Buffalo	75[1]	TCC	Operating
NORTH DAKOTA				
Standard Oil Co. (Ind.)	Mandan	3,700	Ultraformer	Building
Williston Basin Ref. Co.	Williston	300	Catformer	Operating
OHIO				
Ashland Oil & Ref. Co.	Canton	12,000	Fluid	Operating
Gulf Oil Corp.	Cincinnati	15,000	Fluid	Operating
Gulf Oil Corp.	Toledo	13,000	Fluid	Operating
Gulf Oil Corp.	Toledo	10,000	Platformer	Building
Gulf Oil Corp.	Cincinnati	10,000	Platformer	Building
Pure Oil Company	Heath	3,000	Sinclair-Baker	Operating
Pure Oil Company	Newark	4,500	Fluid	Operating
Pure Oil Company	Toledo	11,000	Fluid	Operating
Standard Oil (Ohio)	Cleveland	75[1]	TCC	Operating
Standard Oil (Ohio)	Cleveland	75[1]	TCC	Operating
Standard Oil (Ohio)	Lima	12,000	Platformer	Operating
Sun Oil Company	Toledo	30,000	Houdriflow	Operating
Sun Oil Company	Toledo	10,000	Platformer	Building
Sun Oil Comapny	Toledo	24,000	Platformer	Building
Sun Oil Company	Toledo	35,000	Hydorformer	Operating
OKLAHOMA				
Anderson-Prichard Oil Corp.	Cyril	1,000	Catformer	Operating
Anderson-Prichard Oil	Oklahoma City	1,000	Catformer	Building
Bell Oil & Gas Corp.	Grandfield	1,800	Platformer	Operating
Ben Franklin Ref. Co.	Ardmore	6,000	Fluid	Operating
Champlin Refining Co.	Enid	5,000	Platformer	Building
Champlin Refining Co.	Enid	9,000	Fluid	Building
Cities Service Oil Co.	Ponca City	10,000	Fluid	Operating
Continental Oil Co.	Ponca City	18,000	TCC	Operating
Continental Oil Co.	Ponca City	4,000	Hydorformer	Operating
Continental Oil Co.	Ponca City	5,000	Fluid	Operating
Deep Rock Oil Corp.	Cushing	7,000	Fluid	Operating
Johnson Oil & Ref. Co.	Cleveland	2,000	Platformer	Operating
Johnson Oil & Ref. Co.	Cleveland	1,800	Platformer	Operating
Kerr-McGee Oil Ind.	Wynnewood	6,000	Fluid	Operating
Mid-Continent Pet. Corp.	West Tulsa	7,500	Catformer	Operating
Mid-Continent Pet. Corp.	West Tulsa	22,000	Fluid	Operating
Midland Cooperatives	Cushing	4,500	Fluid	Operating
Phillips Petroleum Co.	Okmulgee	45[1]	TCC	Operating
Sunray Oil Corp.	Duncan	13,000	Fluid	Operating
Sunray Oil Corp.	Duncan	5,000	Platformer	Operating
The Texas Company	West Tulsa	9,000	Fluid	Building
The Texas Company	West Tulsa	15,000	Fluid	Operating
Tide Water Associated	Drumwright	6,750	Hydroformer	Operating
Wilcox Oil Company	Bristow	1,600	Platformer	Operating
PENNSYLVANIA				
Atlantic Refining Co.	Philadelphia	15,000	Catformer	Operating
Atlantic Refining Co.	Philadelphia	33,000	Fluid	Operating
Gulf Oil Corp.	Philadelphia	16,000	Platformer	Operating
Gulf Oil Corp.	Philadelphia	28,000	Fluid	Operating
Kendall Refining Co.	Bradford	1,500	Platformer	Operating
Pennzoil Company	Oil City	3,000	Fluid	Operating
Quaker States Oil Ref. Co.	Farmer's Valley	1,500	Platformer	Operating
Quaker States Oil Ref. Co.	Emlenton	900	Platformer	Operating
Sinclair Oil Ref. Co.	Marcus Hook	36,000	Fluid	Operating
Sinclair Refining Co.	Marcus Hook	16,000	Sinclair-Baker	Operating
Sun Oil Company	Marcus Hook	15,000	Houdriformer	Operating
Sun Oil Company	Marcus Hook	18,000	Houdriformer	Building
Sun Oil Company	Marcus Hook	22,000	TCC	Operating
Sun Oil Company	Marcus Hook	27,000	Houdriflow	Building
The Texas Company	Eagle Point	12,500	Platformer	Building
United Refining Co.	Warren	2,500	Catformer	Operating
TENNESSEE				
MFA Oil Company	Memphis	17[1]	TCC	Operating
TEXAS				
American Liberty Oil Co.	Mt. Pleasant	60[1]	TCC	Operating
Atlantic Refining Co.	Port Arthur	8,000	Catforme	Operating
Atlantic Refining Co.	Port Arthur	30,000	Fluid	Operating
Col-Tex Refining Co.	Colorado City	1,500	Platformer	Operating
Cosden Petroleum Corp.	Big Spring	4,500	Platformer	Operating
Cosden Petroleum Corp.	Big Spring	9,500	Fluid	Operating
Crown Central Pet. Corp.	Pasadena	5,000	Houdriformer	Operating
Crown Central Pet. Corp.	Pasadena	17,500	TCC	Operating
Danaho Refining Co.	Pettus	4,000	TCC	Operating
Danaho Refining Co.	Pettus	17[1]	TCR	Building
Danano Refining Co.	Pettus	1,000	Platform	Building
Eastern States Pet. Corp.	Houston	16,000	Fluid	Operating
Eastern States Pet. Corp.	Houston	7,000	Platformer	Operating
Gladewater Refining Co.	Gladewater	750	Catformer	Operating
Gladewater Refining Co.	Gladewater	600	Cycloversion	Operating
Great Southern Chem. Co.	Corpus Christi	4,000	Platformer	Operating
Gulf Oil Corp.	Port Arthur	30,000	Platformer	Building
Gulf Oil Corp.	Port Arthur	68,000	Fluid	Building
Gulf Oil Corp.	Port Arthur	10,000	Hydroformer	Operating
Humble Oil & Ref. Co.	Baytown	103,000	Fluid	Operating
Humble Oil & Ref. Co.	Bay town	30,000	Ultraforming	Building
Humble Oil & Ref. Co.	Baytown	20,000	Ultraforming	Building
Humble Oil & Ref. Co.	Baytown	27,000	Hydroformer	Operating
R. Lacy, Inc.	Big Sandy	1,000	Cycloversion	Operating
Magnolia Petroleum Co.	Beaumont	13,000	Hydroformer	Operating
Magnolia Petroleum Co.	Beaumont	75[1]	TCC	Operating
Magnolia Petroleum Co.	Beaumont	75[1]	TCC	Operating
Magnolia Petroleum Co.	Beaumont	75[1]	TCC	Operating

Company	Location	Capacity B/SD	Type	Status
Sinclair Ref. Co.	Houston	24,000	Sinclair-Baker	Planned
Magnolia Petroleum Co.	Beaumont	19,000	TCR	Building
McBride Oil & Gas Corp.	La Blanca	750	Catformer	Operating
McMurrey Refining Co.	Tyler	5,000	Platformer	Operating
McMurrey Refining Co.	Tyler	7,500	Fluid	Operating
Onyx Refining Co.	Abilene	750	Platformer	Operating
Pan American Ref. Corp.	Texas City	58,000	Fluid	Operating
Pan American Ref. Corp.	Texas City	7,500	Hydroformer	Operating
Pan American Ref. Corp.	Texas City	21,000	Ultraformer	Operating
Pan American Ref. Corp.	Texas City	68,000	Fluid	Operating
Panhandle Refining Co.	Wichita Falls	1,500	Fluid	Operating
Petrocarbon Chem. Inc.	Irving	1,000	Houdriformer	Operating
Phillips Petroleum Co.	Phillips	35,000	Fluid	Operating
Phillips Petroleum Co.	Phillips	7,500	Fluid	Building
Phillips Petroleum Co.	Phillips	15,000	Fluid	Building
Phillips Petroleum Co.	Sweeny	15,000	Fluid	Operating
Phillips Petroleum Co.	Sweeny	26,000	Fluid	Operating
Phillips Petroleum Co.	Sweeny	16,000	Platformer	Operating
Phillips Petroleum Co.	Phillips	11,000	Cycloversion	Operating
Pontiac Refining Corp.	Corpus Christi	5,000	Cycloversion	Operating
Pontiac Refining Corp.	Corpus Christi	3,600	Fluid	Operating
Premier Oil Ref. Co.	Fort Worth	1,600	Platformer	Operating
Premier Oil Ref. Co.	Fort Worth	3,000	Fluid	Operating
Pure Oil Company	Nederland	10,000	TCC	Operating
Republic Ref. Co.	Texas City	5,000	Platformer	Operating
Republic Oil Ref. Co.	Texas City	17,500	Fluid	Operating
S. Richardson Ref. Co.	Texas City	4,000	Cycloversion	Operating
Shamrock Oil & Gas Corp.	Sunray	1,500	Cycloversion	Operating
Shamrock Oil & Gas Corp.	Sunray	6,000	Houdriformer	Operating
Shamrock Oil & Gas Corp.	Sunray	11,000	Houdriflow	Operating
Shell Oil Company	Houston	12,000	Platformer	Operating
Shell Oil Company	Houston	35,000	Fluid	Operating
Shell Oil Company	Houston	16,000	Platformer	Operating
Sinclair Refining Co.	Houston	40,000	Fluid	Operating
Sinclair Refining Co.	Houston	10,000	TCC	Operating
Sinclair Refining Co.	Houston	24,000	Sinclair-Baker	Building
Sinclair Refining Co.	Corpus Christi	12,000	Hydroformer	Operating
Skelly Oil Company	Longview	2,000	Platformer	Operating
Southwestern Oil and Refining Company	Corpus Christi	5,000	Cycloversion	Operating
Southwestern Oil and Refining Company	Corpus Christi	7,500	Fluid	Operating
Standard Oil of Texas	El Paso	11,500	Houdriflow	Operating
Suntide Oil & Gas Co.	Corpus Christi	15,000	Fluid	Operating
Taylor Oil & Gas Co.	Corpus Christi	45[1]	TCR	Building
Taylor Oil & Gas Co.	Port Isabel	4,000	Platformer	Operating
Taylor Oil & Gas Co.	Corpus Christi	5,000	Platformer	Operating
Taylor Oil & Gas Co.	Corpus Christi	10,000	Fluid	Operating
Texas City Refining Co.	Texas City	18,730	Houdriflow	Operating
The Texas Company	El Paso	7,400	Fluid	Building
The Texas Company	Amarillo	5,000	Platformer	Building
The Texas Company	Amarillo	7,500	Fluid	Operating
The Texas Company	Port Arthur	60,000	Fluid	Operating
The Texas Company	El Paso	4,000	Platformer	Building
The Texas Company	Port Arthur	40,000[2]	Platformer	Operating
UTAH				
Phillips Petroleum Co.	Woods Cross	8,000	TCC	Operating
Salt Lake Refining Co.	Salt Lake City	13,000	Houdriflow	Operating
Utah Oil Refining Co.	Salt Lake City	16,500	Fluid	Operating
Western States Refining Company	No. Salt Lake City	1,000	Houdriformer	Building
WASHINGTON				
General Petroleum Corp.	Ferndale	100[1]	TCC	Operating
General Petroleum Corp.	Ferndale	3,000	Sinclair-Baker	Operating
Shell Oil Company	Anacortes	8,000	Platformer	Building
WEST VIRGINIA				
Elk Refining Company	Falling Rock	1,500	Platformer	Operating
Quaker State Oil Refining Company	St. Mary's	900	Platformer	Operating
WISCONSIN				
Lake Superior Ref. Co.	Superior	1,000	Platformer	Building
Wisconsin Oil Ref. Co.	Sheboygan	1,000	Cycloversion	Operating
WYOMING				
Frontier Refining Co.	Cheyenne	2,000	Platformer	Building
Frontier Refining Co.	Cheyenne	7,000	Fluid	Operating
Husky Oil Company	Cody	1,000	Catformer	Operating
Ohio Oil Company	Lovell	700	Cycloversion	Operating
Sinclair Refining Co.	Sinclair	10,000	Fluid	Operating
Socony-Vacuum Oil Co.	Casper	7,500	TCC	Operating
Standard Oil Company Indiana	Casper	3,700	Ultraformer	Operating
Standard Oil Co. Indiana	Casper	9,000	Fluid	Operating
The Texas Company	Casper	6,000	Fluid	Operating

Foreign catalytic cracking and reforming plants January 1, 1955

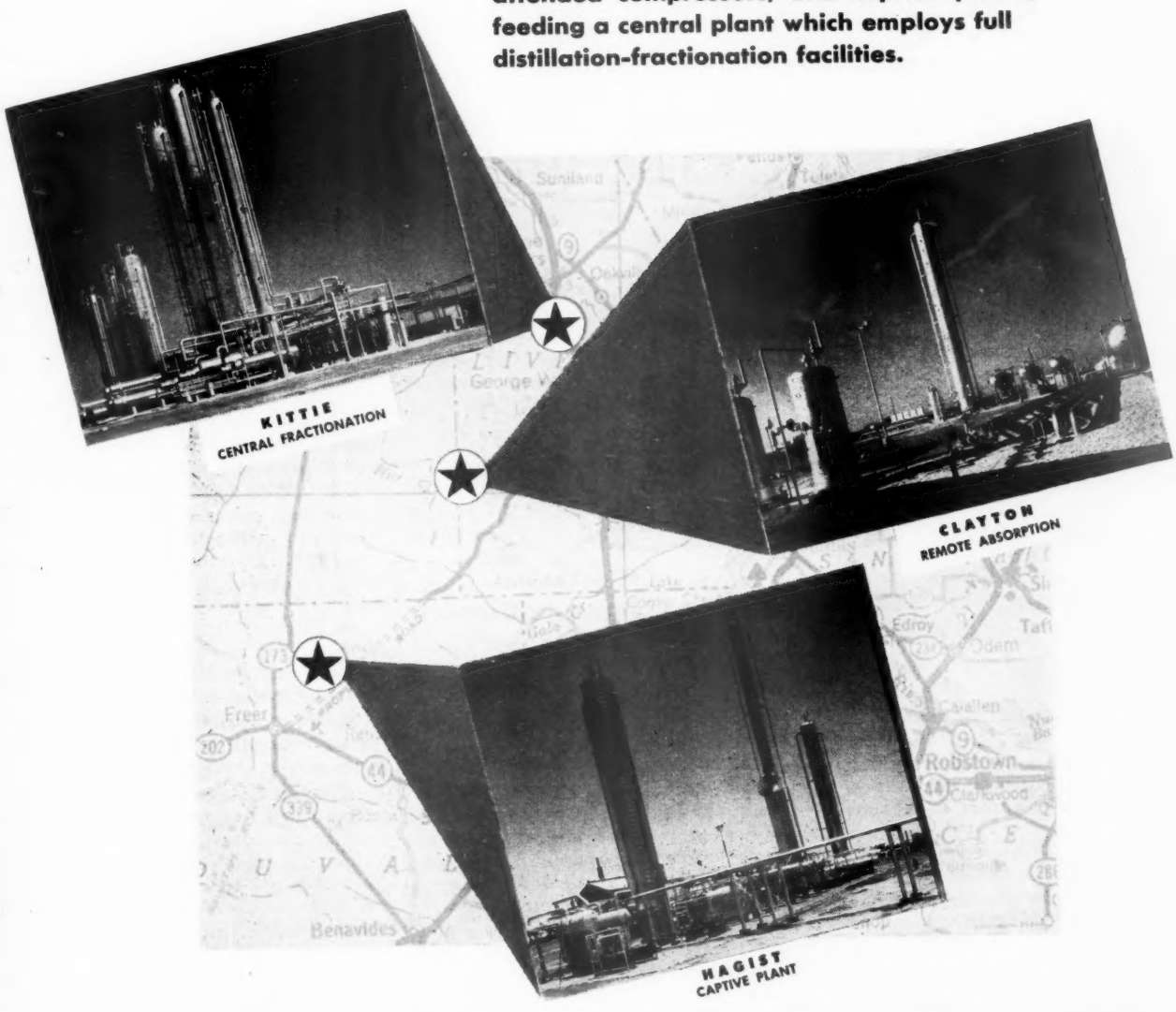
Company	Location	Capacity B/SD	Type	Status
AUSTRALIA				
Bitumen & Oil Refineries Limited	Matraville, N.S.W.	1,500	Platformer	Operating
British Petroleum Co.	Kwinana	6,000	Platformer	Building
California-Texas Oil Company	Turnell	30,000	Fluid	Operating
Shell Oil Company	Geelong	15,000		Building
Standard-Vacuum Oil	Altona	75[1]	TCC	Operating
BELGIUM				
Albatros S. A. B. Raf. de Petrole	Antwerp	3,650	Houdriflow	Operating
Tankage & Transport S. A.	Antwerp	650	Platformer	Building
BRAZIL				
Refineria e Erploacao de Petroles Unias S. A.	Sao Paulo	120[1]	TCC	Operating
CANADA				
B-A Oil Co.	Montreal E. Quebec	17,500	Fluid	Operating
B-A Oil Co.	Edmonton, Alta	2,000	Fluid	Operating
B-A Oil Co.	Clarkson, Ont.	83,000	Fluid	Operating
B-A Oil Co.	Calgary, Alberta	2,000	Catformer	Building
B-A Oil Co.	Montreal, Quebec	13,000	Catformer	Building
B-A Oil Co.	Moosejaw, Sask.	4,500	Fluid	Operating
Canadian Oil Ref. Ltd.	Froomfield	5,000	Platformer	Operating
Canadian Oil Ref. Ltd.		10,000	Fluid	Operating
Canadian Oil Ref. Ltd.		4,000	Platformer	Operating
Canadian Petrofina	Montreal, Quebec	16,000	Houdriflow	Building
Canadian Petrofina	Montreal, Quebec	3,600	Ultraformer	Building
Consumers Cooporative Refineries, Inc.	Regina, Sask.	5,000	Fluid	Operating
Hi-Way Refineries, Ltd.	Saskatoon	2,600	Fluid	Operating
Husky Oil Company	Lloydminster	400	Cycloversion	Operating
Husky Oil Company	Moosejaw, Sask.	1,000	Catformer	Building
Husky Oil Company	Ft. William, Alta.	1,000	Catformer	Building
Imperial Oil	Edmonton	11,000	Fluid	Operating
Imperial Oil	Halifax	27,000	Fluid	Building
Imperial Oil	Ioco, B. C.	13,000	Fluid	Operating
Imperial Oil	Winnipeg, Man.	6,000	Fluid	Operating
Imperial Oil	Sarnia, Ont.	28,000	Fluid	Operating
Imperial Oil	Montreal E. Quebec	16,000	Fluid	Operating
Imperial Oil	Regina, Sask.	7,500	Fluid	Operating
McColl-Frontenac Oil Company	Montreal	12,000	Platformer	Building
McColl-Frontenac Oil Company	Edmonton	5,300	Fluid	Operating
McColl-Frontenac Oil Company	Montreal E. Quebec	16,000	Fluid	Operating
North Star Oil, Ltd.	St. Boniface, Manitoba	8,500	Fluid	Building
Riverlake Oils	Ft. William	1,200	Cycloversion	Operating
Royalite Products	Kamloops, B. C.	1,300	Fluid	Operating
Shell Oil Company	No. Bumaby B. C.	5,000	Fluid	Operating
Shell Oil Company	Montreal E. Quebec	16,000	Fluid	Operating
Standard Oil Co. (B.C.)	Vancouver, B. C.	3,750	Fluid	Building
Sun Oil Company	Sarnia, Ontario	3,000	Houdriformer	Operating
Sun Oil Company	Sarnia, Ontario	11,500	Houdriflow	Operating
Trinidad Leaseholds	Port Credit, Ont.	2,000	Platformer	Operating
ENGLAND				
British Petroleum Co.	Kent	6,000	Platformer	Building
British Petroleum Co.	Llandarcy, Wales	6,000	Platfromer	Building
Esso Petroleum Co.	Fawley	42,000	Fluid	Operating
Esso Petroleum Co.	Fawley	15,000	Fluid Hydroforming	Building
National Oil Refining	Llandarcy	6,000	Platformer	Building
Shell Refining & Mkt. Company	Shell Haven	6,000	Platformer	Building
Shell Refining & Mkt. Company	Stanlow	7,000	Platformer	Building
Vacuum Oil Company	Coryton	60[1]	TCC	Operating
FORMOSA				
Chinese Petroleum Co.	Kaohsiung	6,500	TCC	Building
Chinese Petroleum Co.	Kaohsiung	2,500	Catformer	Building
FRANCE				
Raffineries Francaises	Donges	50[1]	TCC	Operating
S. G. H. P.	Martigues	5,500	Platformer	Building
Socony-Vacuum Francaise	Frontignan	75[1]	TCC	Operating
GERMANY				
B. P. Benzin und Petroleum G. M. B. H.	Hamburg	6,000	Platformer	Building
Deutsche Erdoel, A. G.	Heide	45[1]	TCC	Operating
Deutsche Vacuum Oel Aktien Gesell	Bremen	45[1]	TCC	Operating
Gelsenberg, Benzin A. G.	Gelsenkirchen	45[1]	TCC	Operating
Gelsenberg, Benzin A. G.	Gelsenkirchen	7,500	Platformer	Building
Gewerskchaft Erdoel-Raffinerie Emsland	Lingen	17,500	Houdriflow	Operating
Ruhrchemie, A. G.	Oberhausen	17[1]	TCC	Building
Shell Deutsche A. G.	Hamburg	600	Platformer	Building
HOLLAND				
Shell Oil Company	Pernis	37,500	Fluid	Operating
ITALY				
AGIP Mineraria	Cortemaggiore	20[1]	TCC	Operating
Aquila S. P.A.	Trieste	33[1]	TCC	Operating
Condor, S. P. A.	Milan	75[1]	TCC	Operating
I. L. S. E. A.	Valmadrera	500	Catformer	Building
I. R. O. M.	Venice	10,000		Building
Parmolio, S. A.	Rome	2,000		Operating
Purfina Italiana	Genoa	11[1]	TCC	Operating
Purfina Italiana	Rome	11[1]	TCC	Operating
Socony-Vacuum Italina S. P. A.	Naples	100[1]	TCC	Operating
JAPAN				
Daikyo Oil Company	Yokkaichi	4,200	Houdriflow	Operating
Koa Oil Co., Ltd.	Marifu	1,200	Platformer	Operating
Mitsubishi Oil Co.	Kawasaki	1,600	Platformer	Operating
Nippon Petr. Ref. Co.	Kudamatsu	1,500	Platformer	Operating
Showa Oil Company	Kawasaki	1,750	Platformer	Operating
MEXICO				
Petroleos Mexicanos	Minatitlan	60[1]	TCC	Building
PUERTO RICO				
Commonwealth Ref. Co., Inc.	P. R.	3,730	Houdriformer	Building
Commonwealth Ref. Co., Inc.	P. R.	26,800	Houdriflow	Building
MISCELLANEOUS				
British Petroleum Co.	Aden, Arabia	12,000	Platformer	Operating
British Petroleum Co.	Abadan, Iran	30,000	Fluid	Operating
California-Tex. Oil Co.	Batongas, P. I.	11,000	Fluid	Building
C.E.P.S.A.	Santa Cruz, Teneriffe	5,500	Platformer	Building
Creole Petroleum Co.	Amuay, Venezuela	15,000	Hydroformer	Building
Empresso Columbiana de Petroleos	Barrancabarmejo Colombia	19,000	Fluid	Operating
Koppartrans Oljeaktiebolag	Gothenburg, Sweden	5,000	Catformer	Building
Maden Tekik ve Arama Ensistusu	Batman, Turkey	17[1]	TCC	Building
Mediterranean Ref. Co.	Sidon, Lebanon	650	Platformer	Building
S.A.C.R. de Petroles	Lisbon, Portugal	50[1]	TCC	Building
Societe Cheriffienne des Petroles	Petitjean, Fr. Morocco	17[1]	TCC	Operating
Trinidad Leaseholds	Trinidad, B.W.I.	15,000	Fluid	Operating
C. Shell de Venez.	Cardon	35,000	Fluid	Planned
Arabian American	Ras Tanura, S. Arabia		Fl. Hydroformer	Building

[1] Capacity is 150 to 300 times this nominal type numbered.
[2] [3] [4] No units.

Goliad Corporation Plants take full advantage of...

CAPTIVE PLANT–REMOTE ABSORPTION Techniques

Unique processing of small, scattered gas reserves is daily working for Goliad Corporation through the use of remote absorbers, unattended compressors, and captive plants, feeding a central plant which employs full distillation-fractionation facilities.



GASOLINE PLANT CONSTRUCTION CORP.

ENGINEERS . . . DESIGNERS . . . CONSTRUCTORS

NEILS ESPERSON BUILDING, HOUSTON • WILSON TOWER, CORPUS CHRISTI

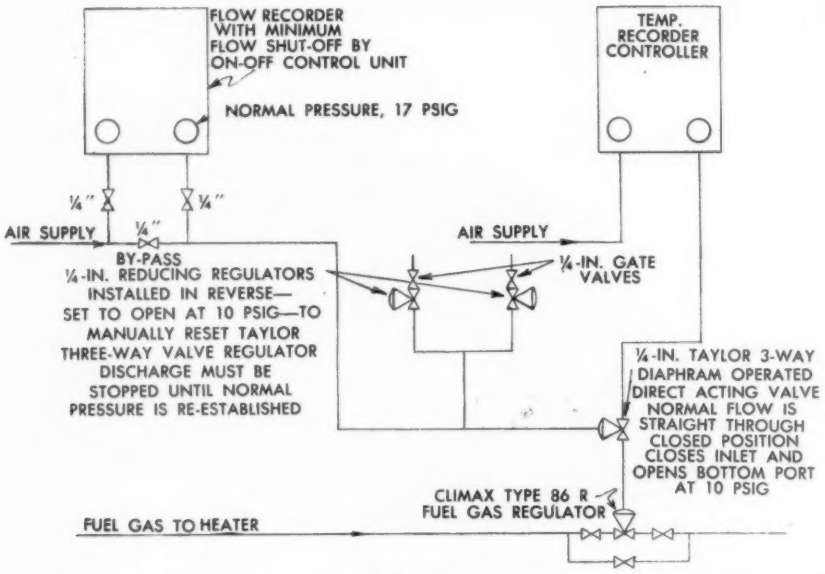
Automatic Minimum Flow Shutdown Service for Direct Fired Oil Heaters*

W. A. ALLEXSON†

Purpose: Shut fire out of heater fire box when oil flow stops.

Description: When oil flow through Alcorn or Petro-Chem type direct fired heater stops abruptly, excessively high pressures and temperatures are created within the oil tubes unless the fire is out of the fire box immediately. The hazard of rupturing tubes and thereby starting serious oil fire is greatly increased under these conditions. An automatic minimum flow shut-down device has been made up to protect these heater tubes from such occurrence.

The hook-up is as shown on the drawing. The original installation on the heaters consisted of a discharge oil temperature recorder controller operating the heater fuel gas regulator and a flow recorder measuring oil flow through the heater. With these instruments in place, it was necessary to buy only a ¼-in. three way diaphragm-operated direct acting valve, two ¼-in. reducing regulators, and an on-off control unit for the flow recorder to make the automatic shut-down installation. The three way valve was placed in the controlled air line between the temperature recorder controller and the fuel gas regulator. The two reducing regulators were connected in reverse in parallel on the controlled air line between the flow recorder and the three way valve diaphragm. The on-off control unit was then installed in the flow recorder instrument. Operation of the device is as follows:


FLOW RECORDER WITH MINIMUM FLOW SHUT-OFF BY ON-OFF CONTROL UNIT
NORMAL PRESSURE, 17 PSIG
TEMP. RECORDER CONTROLLER
¼"
¼"
AIR SUPPLY
¼"
AIR SUPPLY
BY-PASS ¼-IN. REDUCING REGULATORS INSTALLED IN REVERSE— SET TO OPEN AT 10 PSIG—TO MANUALLY RESET TAYLOR THREE-WAY VALVE REGULATOR DISCHARGE MUST BE STOPPED UNTIL NORMAL PRESSURE IS RE-ESTABLISHED
¼-IN. GATE VALVES
¼-IN. TAYLOR 3-WAY DIAPHRAM OPERATED DIRECT ACTING VALVE NORMAL FLOW IS STRAIGHT THROUGH CLOSED POSITION CLOSES INLET AND OPENS BOTTOM PORT AT 10 PSIG
CLIMAX TYPE 86 R FUEL GAS REGULATOR
FUEL GAS TO HEATER

Flow diagram of minimum flow heater shut-down device on R.O. and H.M.O. heaters.

The index pointer on the flow recorder was set at a point slightly below normal recorded flow. As long as the oil flow remains normal, full instrument air supply pressure is transmitted by the flow recorder to the three-way diaphragm valve allowing it to stand open. Controlled air flow from the temperature recorder controller to the fuel gas regulator is therefore not interrupted. When oil flow stops, the indicator pen on the flow recorder drops below the index pointer and trips the flapper away from the nozzle which bleeds the air pressure from the line supplying the three-way diaphragm valve. The two ¼-in reducing regulators (installed in reverse) are set to open to the atmosphere when line pressure drops to 10 psig.

This provides additional means for venting the controlled air from the line between flow recorder and three-way valve off to atmosphere. As the controlled air pressure drops below 10 psig, the three-way valve closes off the controlled air flow from the temperature recorder controller to the fuel gas regulator. Simultaneously a bottom port in the three-way valve is opened and vents air from the line between this valve and the fuel gas regulator diaphragm. The fuel gas regulator then closes and fire is extinguished in the fire box. If the oil flow is re-established to normal in a short time, the flapper again covers the nozzle and allows controlled air to again flow toward the three-way valve. This air pressure would open the three-way valve and consequently the fuel gas regulator if allowed to build up. Since it is desirable that the heaters not be fired up until the operator desires, the air pressure is bled off from this line through the two reducing regulators to atmosphere. Caution must be taken to provide sufficient bleed-off capacity to prevent build up to 10 psig. Should the pressure reach 10 psig, the reducing regulators would close and allow normal controlled air to pass from the flow recorded to the three-way valve. Two ¼-in. reducing regulators are used on the installation at the plant where this device was instigated. In order to place the shut-down device back in operation after normal oil flow is resumed, the plug valve downstream of the fuel gas regulator and the one on the by-pass around this regulator must be in closed position. The two ¼-in. gate valves downstream of the ¼-in reducing regulators are manually closed by the operator. This permits controlled air pressure to build up again and open the three-way valve. This allows the controlled air to flow to the fuel gas regulator. The plug valve downstream of the regulator is opened and the heaters lighted. Normal service is thus established.

When it becomes necessary to reduce the oil flow to a heater by stopping one of the two pumps in this service, the automatic shut down mechanism must be taken out of service to prevent completely cutting off the fuel gas supply to the heater. This may be accomplished by opening the by-pass between the air supply and controlled air lines on the flow recorder instrument, thereby maintaining the three-way valve in open position.

This plant has two such automatic shut down mechanisms in operation on Alcorn heaters and four on Petro-Chem heaters. They have proved to work perfectly on numerous occasions since their installation approximately one year ago.

*NGAA Permian Basin regional meeting.

†Assistant superintendent, Shell Oil Company, Notrees, Texas.

Mixed streams of gases or liquids can be separated by the size of their molecules in new product

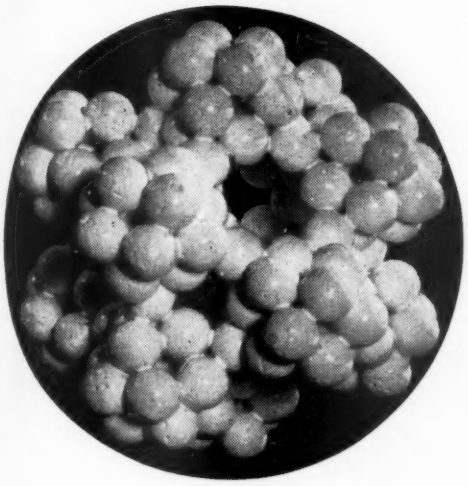


Fig. 1. Model crystal unit shows arrangement of atoms. Each crystal holds millions of gas or liquid adsorbing cells.

Molecular 'Sieves' Offer New Separation Process

Eugene B. Brien*

COMPLETELY new commercial adsorbents operating on a principle entirely novel to industry were announced recently by Linde Air Products Company, Union Carbide and Carbon Corporation. The new adsorbents are synthetic zeolites and are said to separate molecules of liquids and gases mainly according to size. Called molecular "Sieves," they withhold certain compounds in mixed streams and permit others through; they can thus serve to purify or separate gases and liquids in mixed streams.

The crystalline (physical) structure of the atoms in the zeolites (sodium, calcium, silicon, aluminum, oxygen) contains many small and extremely uniform cavities interlaced with still smaller pores (Fig. 1). In their normal state, the zeolites hold water molecules in their cavities; when the water is driven out in manufacturing the dehydrated crystals keep their original structure unchanged and the cavities can then receive molecules of similar or smaller sizes. At the same time, the crystals retain such a strong affinity for water that, if water is lacking, they will accept other molecules.

*Eastern Editor.

EXCLUSIVE

These two principles, the screening action of the cavities and the adsorptive attraction of the crystals, are said to show particular promise for the refining industry and to supplement crystallization and distillation as separating processes, and perhaps eventually to be competitive with distillation.

Two Streams Separated

In a mixed stream, two products may be separated by means of a packed column or bed made from one of the two types of "sieves" now available. The molecules in the stream that are sufficiently small to enter the openings in the adsorbent are held there; the molecules too large to enter the pores pass through the bed. In an ethane-propane stream, the ethane molecules enter the openings, as both molecules and openings are about 4 Angstroms in diameter (about 16 billionths of an in.). The propane molecules, however, are about 5 Angstroms in diameter. Excluded from the openings by their large size, they pass on through the column and are removed from the system. The ethane is then collected separately.

A second type (5 Angstroms in diameter) reportedly adsorbs straight-run hydrocarbons (as n-hexane) and lets branched-chained hydrocarbons (iso-

Fig. 2. Available as a powder, typical sieves are extruded as cylindrical pellets and resemble rice or barley.

TABLE 1. Various compounds adsorbed and not adsorbed by the two commercially available molecular sieves:

Adsorbed on the two commercial sieves	Adsorbed on one type alone	Not adsorbed on either type
Water	Propane and higher n-paraffins up to at least C_{14}	Iso-butane and all iso-paraffins
Carbon dioxide	Butane and higher n-olefins	Iso-propanol and all iso-, secondary, and tertiary alcohols
Carbon monoxide		
Hydrogen sulfide	n-Butanol and higher n-alcohols	Benzene and all aromatics
Sulfur dioxide		
Ammonia	Cyclopropane	Cyclohexane and all cyclics with at least 4-membered ri gs
Nitrogen, Oxygen	Freon 12	Carbon tetrachloride
Methane, Methanol		
Ethane, Ethanol		Hexachlorobutadiene
Ethylene, Acetylene		Freon 114
Propylene, n-Propanol		Freon 11
		Sulfur hexafluoride
Ethylene oxide		Boron trifluoride
		Molecules larger than 5.0 Angstroms

hexane) and cyclics (benzene or cyclohexane) go through the bed because the latter two are larger than 5 Angstroms. Thus, the "sieve" can adsorb n-hexane out of methylcyclohexane or n-tetradecane out of benzene (Table 1).

This method of separating gases and liquids is of particular value when two compounds with close boiling points must be separated and distillation cannot be used. N-heptane and methylcyclohexane—whose boiling points differ by less than two degrees Centigrade—are effectively separated according to their molecular diameter, the company states.

The Linde sieves have several other valuable characteristics. It is claimed that they can adsorb large quantities of a material making up a small part of a gaseous or liquid mixture. Type 4A can adsorb 19 per cent of its own weight of water from a gas with only 2 per cent relative humidity—equal to about 5 times the water adsorbed by silical gel or activated alumina. Hence, materials can be more fully purified with this adsorbent than with presently available ones. This property is said to make waste gas streams a proper field of application.

Materials Hold Strongly

The new adsorbents hold materials so strongly, it is said, that they can adsorb materials at much higher temperatures than alumina or silica gel; they effectively remove water from air at 212 F when others fail.

They show strong affinity for polar molecules (hydrogen sulfide, alcohols, CO) over non-polar molecules when both are of the same size. Refinery gases and synthesis gases may thus be purified of polar materials.

They also hold unsaturated molecules (ethylene, acetylene, propylene, butylene) and permit saturated molcules to pass through; that is, they adsorb ethylene and let ethane go through.

They may be used to purify gas streams containing only traces of CO, CO_2, ammonia, hydrogen sulfide, and mercaptans that may poison catalysts, inhibit reactions or that may be toxic or corrosive.

They are said to be quick adsorbents well suited for continuous adsorption processes and thereby can lower processing costs.

Reactivation is reportedly a simple heating and purging process and the adsorbed materials can be reclaimed. The same bath of sieves can be used over and over again in a cyclic process.

The two types the company is offering in three different sizes or forms are: A crystalline powder—for use with agitation—and two pellets, ⅛ in. and 1/16 in. in diameter (Fig. 2). * * *

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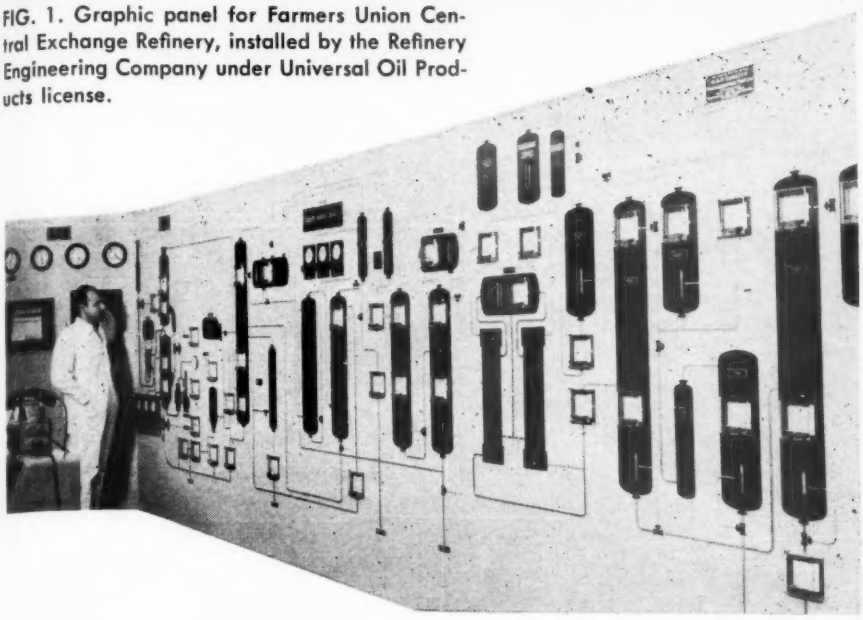
FIG. 1. Graphic panel for Farmers Union Central Exchange Refinery, installed by the Refinery Engineering Company under Universal Oil Products license.



Trends in

refinery instrumentation

R. A. Schlegel* and S. D. Ross*

MUCH is heard today of the word *automation*—quite simply defined as "the act or method of making a manufacturing, or processing, system partially or fully automatic." Certainly, this technique is not new to the refiner who has for several decades led the trend toward fuller and more integrated use of industrial instrumentation.

And so it is that a summary of recent developments in refinery instrumentation presented nearly two years ago** touched upon almost every significant trend in instruments and control techniques that might be mentioned today. The intervening period has brought forth few really new principles of design or application, but much has been done by both instrument manufacturers and refinery engineers in bringing these developments along toward practical adoption as "standard instrumentation." As is true in any growing science, much has been learned in the hard school of experience.

This article is, therefore, devoted largely to a re-evaluation of the newer tools and techniques. Electronic control, graphic panels, data handling systems, on-stream analysis and the like are summarized with significant developments in each briefly outlined.

The Modern Graphic Panel

Part 1 of this series of articles reviewed past progress in refinery instrumentation through what were termed its three distinct periods of advancement—the accounting and recording era, the automatic control era, and the transition era with its "alter and improve" and "new approach" philosophies. The logical development of graphic panels out of the trend toward centralization of recorders and controllers is also discussed. Today, almost without exception, graphic panels are employed on all new or modernized instrument installations in the refinery. Design principles of these panels, however, have advanced considerably in the past two years.

Earlier efforts to incorporate symbolic process systems along with miniature instruments on a centralized panel often suffered from overzealousness to include too much information. Too many pieces of accessory equipment and vessels, as well as instruments for secondary functions were crowded on the panel. The result in many cases was a cluttered effect which tended to be confusing to the operator and thereby to defeat the very purpose for which the panel was designed.

Experience has taught panel users and designers that better results in operator training and use can be achieved if the process diagram is simplified to show only essential process units and major process lines with accompanying instrumentation clearly associated with these units and lines. Secondary instruments of miniature or larger size for auxiliary recording or controlling functions might even be relegated to sections or wings beside the graphic portion (Fig. 1).

Miniature Instruments Modified

Experience in the use of graphic panels and construction of control rooms for them also disclosed some much needed changes in the design of miniature instruments. Formerly, in

This Article, No. 14, is the final one in the most comprehensive series of articles on instrumentation, its trends, methods of application and of servicing, that has been published to date in any petroleum refining publication. It brings us up to date in this all-important and still rapidly growing field, a field in which every process operator, in ANY industry is interested vitally.

Increasingly important is the relatively new field of electronic (electric) control systems, new star in the field of automation. From those in the two industries who are in the know, it comes that these industries should begin immediately and enlarge efforts to develop a "water-tight" set of standards in many phases of this field, especially including explosion-proofing requirements and specifications. These matters, by no means insurmountable, merely evidence the growing pains of a very dynamic phase of both industries, instrument, and petroleum refining-petrochemicals.

EXCLUSIVE

*Minneapolis-Honeywell Regulator Company, industrial division, Philadelphia, Pennsylvania.

**The Petroleum Engineer, July, 1952 (Part I of a series which appeared in subsequent issues).

the installation of panels with larger-sized recorders and controllers, construction of the panel base and control room walls came first, with the panel proper, and then the instruments, installed last. Instrument components were thus kept away from the dust and dirt caused by the earlier construction work.

On the other hand, the graphic panel is generally completely assembled, wired, and piped elsewhere before it is installed in the control room. This means, in effect, that it has to have a control room "built around it." Thus, any instrument components left on the panel would be subject to all the dust and dirt of later construction work.

Newer miniature instruments have been designed to solve this installation problem. The complete chassis, with recorder components and control adjustments, can be packaged and shipped separate from its case. The case, with an air pressure regulator and air-to-valve pressure gage for manual control, can be installed when the panel is built. This permits checking of all field and panel wiring and piping connections, stroking of control valves, and other checks of the system operation before start-up.

After construction work is completed, the chassis can be quickly and easily inserted in the case and connected to electrical and pneumatic lines (Fig. 2); and the "stacked diaphragm" controllers in the control room can be mounted on the back of the case or panel. All working parts of the instruments and controllers are thus protected from dust and dirt.

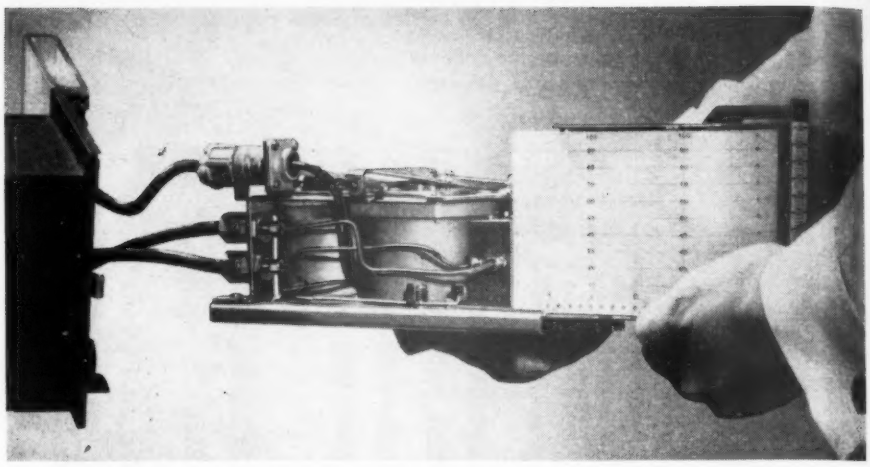


FIG. 2. Chassis of miniature recorder completely withdrawn from its case. Electrical and pneumatic connections are made at rear of chassis.

Control System From Building Blocks

Miniature instruments for graphic panels were developed concurrently with the adaption of the pneumatic-balance principle in separate stacked diaphragm controllers. This controller receives air pressures proportional to the measured variable and set point and transmits a control air pressure to the valve. Being connected in the control system solely by pneumatic tubing lines, it can be mounted wherever desired without regard to the panel location. Thus, aside from uses in conjunction with graphic panels, this new control component has brought a high degree of flexibility in refinery instrumentation.

With high sensitivity, and particularly when close-coupled in combination with the newer mercuryless flow transmitters of the diaphragm type for flow control, these new controllers have been setting new standards of performance in the past few years. Most recent developments in this equipment have been largely refinements in design—for example, to provide quick and easy removal of a control unit mounted on the rear of a miniature instrument or at the valve location, and to afford needed variations in control modes by interchangeable units. Regardless of whether the graphic panel as we know it today will remain unchanged or be, as some predict, merely a step in a transition to other forms of supervisory control, this building block approach to refinery instrumentation appears to be an established technique.

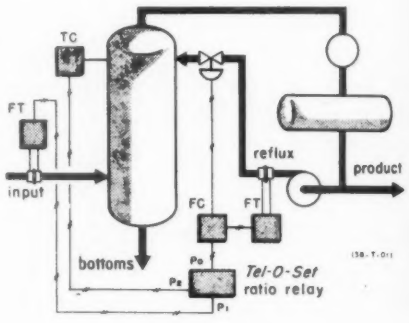
Pneumatic Relay for Cascade or Ratio Control

For some years refinery instrumentation has included various forms of interconnected controls; for example, in cascade control one controller is used to reset the set point of a second controller, instead of a control valve directly. Or, one controlled flow is held in a constant relationship with a "wild" flow by means of a ratio flow control.

Along similar lines, it appears that the use of on-stream analyzers may well be tied in with controllers for more than one process variable by variations of such interconnected systems. Some form of computer may well be designed to operate for an analyzer input signal or several input signals and perform certain operations on these signals to determine what changes should be made in the set points of several secondary controllers. Such a system would indeed be a major step toward complete automation of the refinery or petrochemical plant.

One simple form of computing device is an all-pneumatic relay which has been designed for use as an integral component of cascade or ratio control systems. The relay makes possible the interconnection of three process variables to effect the positioning of one final control element. A common use of it is where the ratio of one variable to another must be *continuously adjusted* as a third variable changes in value. Being essentially a pneumatic multiplying relay, however, it has other uses in interlocked control systems.

FIG. 3. Application of ratio relay in a distillation control. (P_0 — output air pressure from relay pneumatically sets index of reflux flow controller; P_1 — input air pressure from column feed transmitter; P_2 — ratio setting input air pressure from column temperature controller).

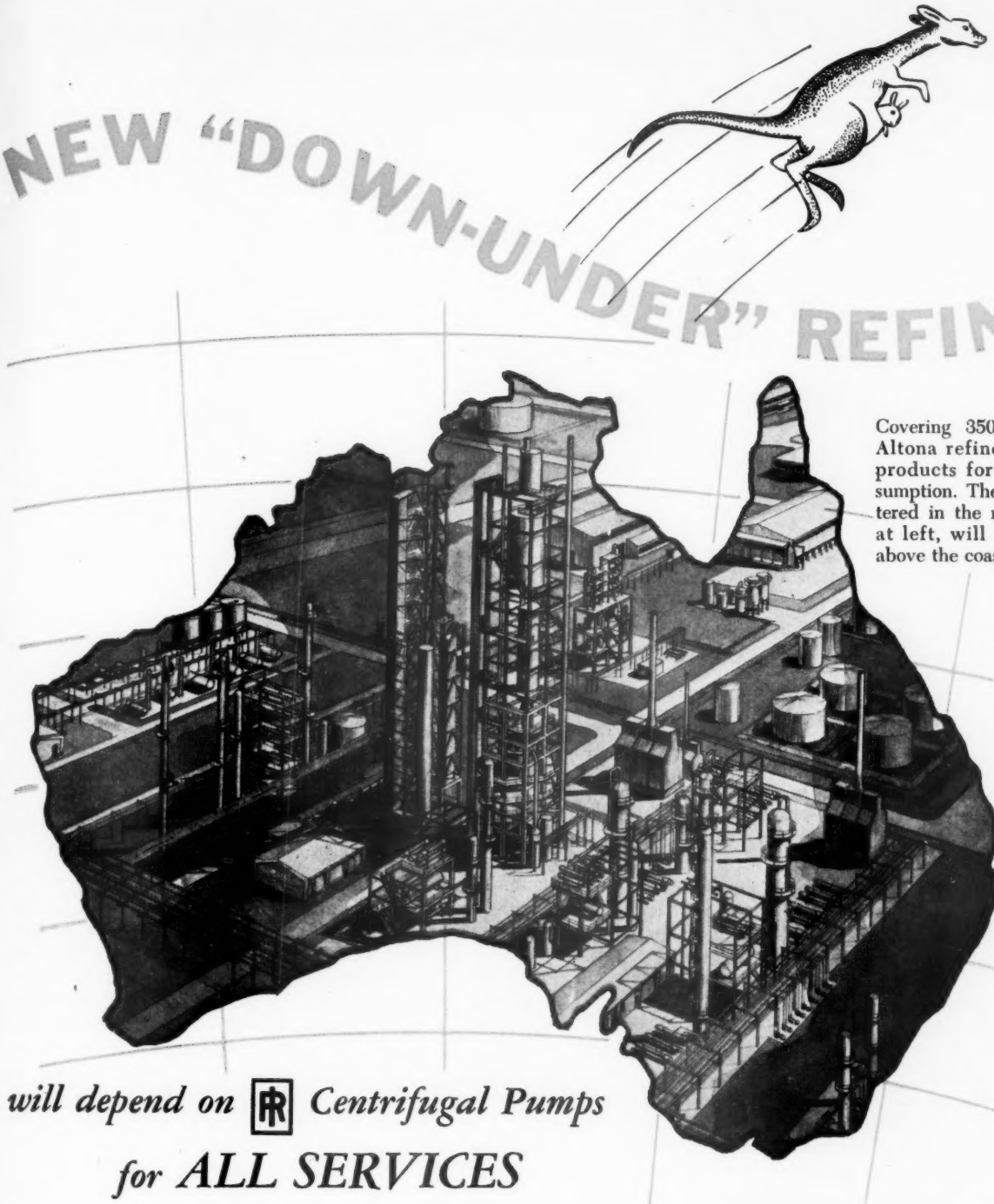


An example of this relay in use should serve to explain its basic function and give some idea of its flexibility in application. In a typical distillation control system (Fig. 3) the relay is used to reset the index of the reflux flow controller on the basis of feed flow and column temperature. Ratio of feed to reflux flows is thus varied continuously and automatically in accordance with the column temperature.

Electric Control Systems

One significant new development which is being watched carefully by refinery and instrument engineers is the all-electric control system. For many years electrical equipment in refinery instrumentation has been confined largely to the electronic potentiometer which has been almost uni-

NEW "DOWN-UNDER" REFINERY



Covering 350 acres, Stanvac's Altona refinery will produce products for Australian consumption. The cat-cracker, centered in the map-outline photo at left, will tower 16 stories above the coastal plain.

will depend on I-R *Centrifugal Pumps for ALL SERVICES*

Now under construction near Melbourne, Australia, the new refinery of Standard-Vacuum Refining Company, Ltd. will have a capacity of 25,000 barrels per day. Erected by C. F. Braun & Co., Alhambra, Cal., this $37,000,000 project will constitute a complete refinery, with a half-dozen main process units, including crude distillation, catalytic cracking, catalytic reforming, alkylation and treating facilities.

It is of interest to note that *centrifugal pumps* throughout the entire installation will bear the familiar I-R nameplate. These Ingersoll-Rand pumps will be used for many refinery services—still reflux, boiler feed, gasoline transfer, etc. Their *proved dependability* is a matter of record throughout the world-wide petroleum industry.

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10-39

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versally used for temperature *measurement* by means of thermocouples. Such instruments have been widely adopted also for automatic control, but almost exclusively of the pneumatic type.

Instantaneous transmission of measurement and control signals has long been an appealing feature of electric measuring and controlling systems. Many of the newer refinery installations and proposed installations are being designed with little or no storage capacity between units. This places even more importance on the use of complete, centralized instrumentation, often for an entire refinery. Lengths of instrument lines in such installations are thus approaching the point where the performance of pneumatic systems may begin to suffer; hence the intense interest in the possibilities of electric systems.

Furthermore, in installations subject to freezing weather, an all-electric system would eliminate the need for conditioning of instrument air. What may prove more important in the future, however, is the ease with which electric signals can employ newer types of sensing elements and can be connected to logging and computing systems.

Limitations of Electric Systems

Electric systems have certain limitations which the industry well recognizes and which it realizes must be overcome before electric systems can be employed extensively in refinery instrumentation. One drawback to maximum effectiveness of such a system is the design of a suitable electrically-operated valve with a speed of response to match the rest of the control loop components. At present, the reliable workhorse, the diaphragm motor valve, must still be used with an electro-pneumatic transducer at the valve; this requires the added expense of piping and maintaining an air supply to all valve locations, along with electric lines.

Furthermore, to achieve the design refinements available in pneumatic transmitters and other pneumatic control components with their degree of simplicity and reliability, much work remains to be done on electric control systems. Some of the major factors to be established as standards for refinery applications are discussed briefly.

(1) **Transmission Signals:** Just as was true in pneumatic transmission some years ago, one primary objective in the design of newer electric systems is for a *standard* transmission signal, equivalent to the standard 3 to 15 psi range universally adopted for pneumatic systems. High transmission accuracy is, of course, another major requirement of the electric system. In addition, simple two-wire transmission over the extremes of distance expected in newer refinery installations is highly desirable.

The signal should be acceptable as an input to analog computers and analog-to-digital conversion units, so that the use of logging and computing equipment is facilitated. It should also be easily cascaded in control systems.

Flexibility of the electric system should be such that indicating, recording, or checking instruments and controls can be installed at any point in the control loop. Affects of stray pick-up must be minimized.

(2) **Transducers for Process Variables:** Temperature, pressure, flow, and other variables must be converted accurately to current. The thermocouple inherently provides a simple means of signal transmission and can be converted into a compatible current signal in the control room. The variable differential transformer has been a simple and accurate means of converting motion into an alternating current. Because it requires that the primary element move, however, there is reason to believe that the principle of stationary electrical-balance primary elements (equivalent to their present day pneumatic counterparts) are preferable and quite practical. As in their pneumatic counterparts, the electric-balance principle promises higher sensitivity and accuracy, as well as increased stability due to the feedback or rebalancing action employed.

(3) **Explosion-Proofing:** The problem of explosion-proofing requirements in the refinery area is probably the most baffling one that faces both the manufacturer and user of electrical equipment today. Some refineries have employed electric flow transmitters of the inductance bridge type for years, and more recently electrical scanning and logging equipment has employed field-mounted components in several plants. In general, however, no consistent standard electrical code has been established throughout the industry.

Some companies are considering the "intrinsically safe" classification of equipment as generally adopted in England. The wide acceptance of the Class I, Group D, Division 2 classification for control rooms in U. S. refineries has permitted the widespread use of electronic instruments in this location. In other areas, however, there is a great need for clarification of what is acceptable and what is not in the explosion-proofing of electrical equipment. This is a challenge for the refiner, working with such groups as the joint API-ISA committee on Hazardous Locations, to clear the path for wider use of electric control systems.

By design of the electric transmission system, it is possible to avoid the need of an electric power supply at the transmitter and permit its location in the control room. With regard to the use of an electro-pneumatic transducer at the valve, or an electrically-operated valve, there still remains a question as to the exact explosion-proofing requirements.

(4) **Design in Miniature Instruments:** It would appear that the electric control system can be adapted to provide an exact equivalent to present day pneumatic instrumentation for graphic panels. It is conceivable that such a system can even offer greater simplicity of component construction and ease of maintenance than its pneumatic counterpart.

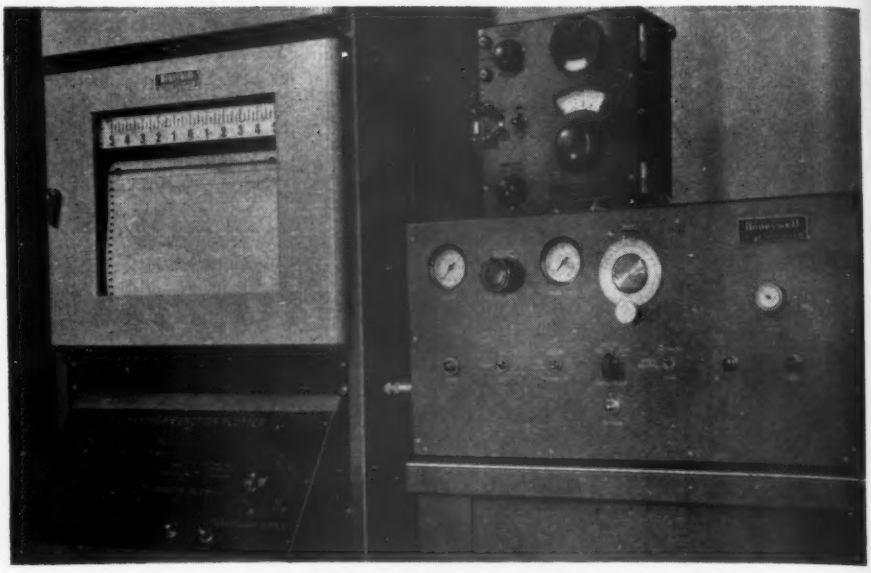
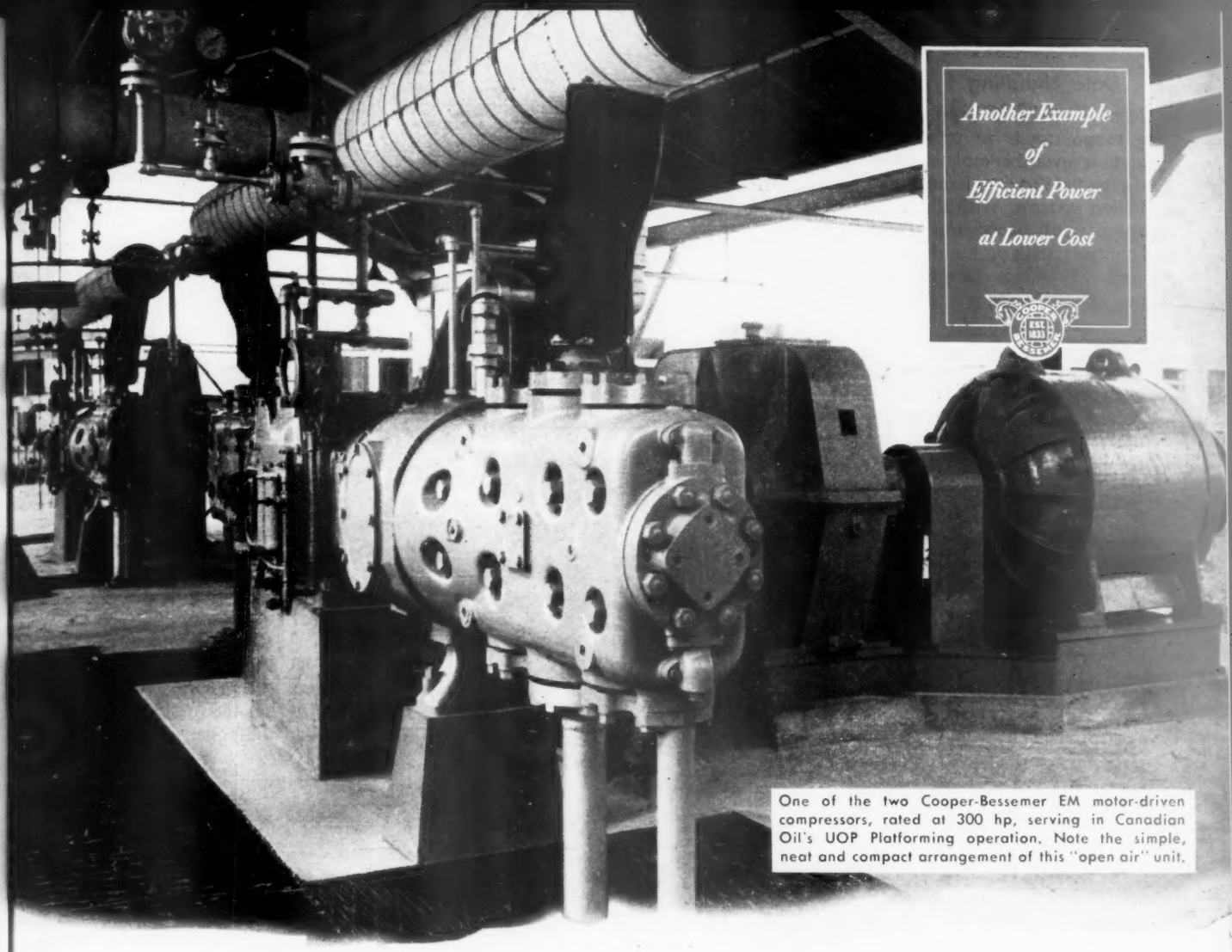


FIG. 4. Servo analyzer system for the plotting of frequency response data on control and process equipment.



One of the two Cooper-Bessemer EM motor-driven compressors, rated at 300 hp, serving in Canadian Oil's UOP Platforming operation. Note the simple, neat and compact arrangement of this "open air" unit.

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XUM

Data Handling Systems

Perhaps one of the most significant long range trends in refinery instrumentation toward complete automation lies in the field of data handling or data reduction systems. With the increasing complexity of processing techniques and controls, data on hundreds of temperatures, pressures, flows, etc., must be put in usable form to be of maximum benefit.

Such data, for example, may serve the prime purpose of present day instrumentation in guiding process operation, but as a part of a complex and completely automatic system employing numerous feedback lines. In the refinery of the future, and companion petrochemical plants, increased emphasis will be placed on instrumentation to provide higher product quality, better yields of various cuts, and greater operating efficiency in general.

As a management tool, completely integrated and extensive data handling systems for individual units or an entire refinery are expected not only to aid in more economical and intelligent operation, but also to provide more accuracy in cost accounting of charge stocks, intermediates, and products. It is considered quite feasible that they may even be an aid to management in more closely relating market demands to production of refineries and petrochemical plants. Systems for handling information from a large number of variables and being designed to provide one or more of the following functions:

(1) automatic measuring
(2) automatic logging
(3) visual digital indication
(4) automatic scanning and monitoring
(5) automatic control

New data handling techniques are employing combinations of new equipment with standard instrumentation to provide these functions. For example, visual digital indication could be provided in a logging system by addition of one form of what is termed a *readout* device. A whole new terminology is coming into the instrumentation field with system components, such as *servo positioner* and *linearizer, digital converter,* and *programmer.* And a whole class of accessory readout devices are being discussed, such as *digital indicator, card punch, tape punch,* and *digital computer.*

It is beyond the scope of this review article to discuss these devices in detail, but there seems little doubt that more will be written and discussed on this subject in the near future. Increased emphasis in refinery operations on product quality, more accuracy in cost accounting of materials and products, yield studies, and greater operating efficiency in general will certainly keep the spot light on completely integrated and extensive data handling systems. Costs of such systems, while high, are expected to pay for themselves by their valuable information.

One refinery is installing an automatic logging system to record pressures, temperatures, liquid levels, and flows from over 100 points every hour, with continuous integration of flows. The records are to print digitally on a single tabular chart, similar to the familiar refiner's log sheet.

"On-Stream" Analysis

Continuous product quality analysis as a means of process control has been an intriguing and promising topic for discussion in refinery instrumentation for about seven years. Part 1 of this article series touched upon this subject, pointing out the obvious advantages visualized in terms of better control, improved equipment design, higher yields, and the like. There seems little question that the time consuming sample-to-laboratory methods in analysis satisfy no one, but the problems of bringing a satisfactory continuous analyzer into the control loop are many.

Finding a suitable measuring system for the specific product in question is not simple, but much progress has been made in adapting the various infra-red and other spectrometric analyzers for such measurements. Lags in measurement must, of course, be minimized; maintenance, while expected to be higher than for conventional instruments, must be reasonably low. Costs of such equipment too are relatively high, and must be economically justified in increased yield or improved product quality.

Automatic control from these analyzers is not as yet in common use. The process itself introduces excessive lag from the time that correction action, based upon an analysis reading, is introduced. One refinery believes that this limitation could be overcome only by the installation of six or eight analyzers at various critical points in the process line, but feels that this could not be economically justified today.

Further control studies may bring other more practical solutions to this problem. The pressure on such studies will be in direct ratio to expressed needs for the equipment; requirements for cuts of specific purity with narrow tolerances, as might well be found in newer petrochemical processes, for example, will definitely emphasize the need for accurate measurement and control systems incorporating analyzers.

Theoretical Approaches to Automatic Control

Part 1 of this series reviewed the increasing activity in a new approach to control problems, termed "servomechanism techniques" because much of the theory was carried over from the servo field. The promise of benefits to the petroleum processor is still there, but so are the problems. A number of refining companies have research work being conducted in frequency response analysis and much has been learned of the techniques and value of data obtained.

It has been found that as a selection tool for components of a control system, frequency response data provides a means of microscopically evaluating dynamic performance. It may be a question at times whether such an analysis is too fine, in view of limitations imposed by other components of the system—including the process, which is oftentimes the biggest limitation. However, when all other characteristics of the tested component are equal, frequency response tests do offer a very accurate means of selection.

Yet, it is in the area of studying process controllability as a factor in process design and improved application of control equipment, that the servo techniques offer the greatest opportunity for technological advance. A number of petroleum companies are becoming more active in this work and obtaining some promising results in spite of the great difficulties. Obtaining such data on heat exchangers, distillation columns, and other process equipment presents a tremendous challenge to the industry, but the rewards in improved processing, better control, and more efficient use of process equipment appear to make this effort well worth the time and money.

As an aid in the collection of frequency response data accurately and rapidly, a system termed a "servo analyzer" has been marketed (Fig. 4). The system provides the means for automatic measurement and plotting of phase and attenuation characteristics by the use of mechanical, electrical, or pneumatic sine waves.

Such a system permits, in a matter of minutes, measurement and recording of frequency response characteristics of piping, tanks, valves, actuators, control instruments, and other units of process equipment to help predict how they will perform in actual operation. It can also be used for analog tests where process or equipment characteristics are simulated in the laboratory, and for trouble shooting on a going process. * * *

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In 1955

Additives for Fuels and Lubricants

Refining industry's bill for addition agents, product improvers, runs into hundreds of millions of dollars annually

C. M. Larson

AT the start of 1955 there were more than 58,000,000 cars and trucks serviced by more than 210,000 gasoline service stations in operation in this country, using more than a billion barrels of gasoline per year. It is estimated that 1955 total demand will be 3.5 per cent greater than 1954. Constant daily efforts on the part of the petroleum industry in cooperation with the automotive industry, through extensive research and development, and full-scale tests, give the American driving public the highest quality in gasolines and lubricants. Although there are different formulations for gasolines and automotive lubricants, the end is the same, namely, optimum performance, availability, and life of the vehicle.

Whether the product be gasoline, motor or gear lubricants, domestic heating oil, diesel fuel, or industrial lubricants, including cutting fluids, the end-use built around the needs of the equipment concerned controls the properties of the finished fuels and lubricants to be manufactured. In the last analysis, it is the machine that tells us what performance level it needs. In nearly every instance additive agents are used for imparting new, or for improving existing characteristics of petroleum products and without them our present mechanical output and service performance would be impossible.

EXCLUSIVE

Gasoline

Introduction of a new gasoline additive is no hit-or-miss proposition. Behind each one are months, and often years, of research and development work and exhaustive testing in the laboratory and in fleets on the road. Not only must the additive do the job for which it is intended, but it must be trouble-free from the time it enters the fuel tank of the vehicle until the exhaust gases pass out of the tailpipe, not only for 100 miles but for thousands of miles of service.

As gasoline is the largest single refinery item, let's see what fuel additives are used to better engine performance. Table 1 illustrates these additives and also lists the estimated annual consumption for the year 1955.

TABLE 1. 1955 Estimated annual consumption of additives for gasoline.

Additive	Approximate dosage	Million pounds	Million dollars
Tetraethyl lead	nil–3 ml per gal (max)	400–450	250
Antioxidants	2–16 lb per 1000 bbl	6	7
Metal deactivators	1–3 lb per 1000 bbl	1.5	2
Corrosion inhibitors	10–50 ppm	5	1
Anti-icing	½–1%	190	10
Pre-ignition preventers	0.01–0.02%	8	3
Upper cylinder lubricants	A few tenths of 1%	140*	5
Dyes and decolorizers	A few parts per million	1	1

* Annual consumption of total upper cylinder lubricants.

The use of any or all of the additives shown in Table 1 must produce desirable characteristics at a cost that is not prohibitive to the refiner. Also, the sales merchandising people must be able to capitalize on such benefits through their advertising copy. Today addition agents of all types have become a key selling point of modern gasolines. The public appears anxious to try modern gasolines with new performance characteristics gained through the use of additives. The use of additives has become an integral part of marketing petroleum products, as well as an important part in the actual refining and production of modern gasolines.

1. **Antiknock Agents for Gasoline**—In 1955 there will be a marked increase in compression ratios (7.99:1 averages for 1955 cars vs. 7.64:1 for 1954), and more than 47 per cent of 1955 car production or an estimated 2,643,000 new cars will be in the premium gasoline market. This means that more than 26 million cars at the end of this year will be premium fuel customers. Such fuels are now running 90 and 97 octane research, and will go higher. This year the total gasoline consumption will run about 54.7 billion gallons, of which 18.4 billion will be premium grade. Thus an increase in the amount of tetraethyl lead sold from a total of 225 million dollars at the end of 1953 to an estimate of 250 million dollars in 1953, is anticipated.

2. **Gasoline Antioxidants**—The use of antioxidants inhibit gum formation by oxidation and polymerization in storage and prevent potential gum forming substances from depositing in gasoline engine fuel lines, carburetor jets, and on intake valves. In some cases, existent gum (ASTM-D-381) may appear to be lowered slightly by the addition of antioxidants. This is due to the fact that oxidation is prevented during the evaporation step. Antioxidants will not reduce the gum that has already formed. Antioxidants of the amino phenols, alkylated phenols,

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POWELL VALVES FOR MODERN INDUSTRY

FIG. 2193—Ni-Resist* Gate Valve for 200 Pounds W.O.G.

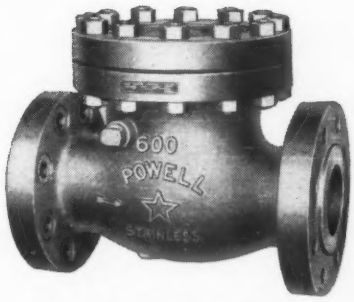
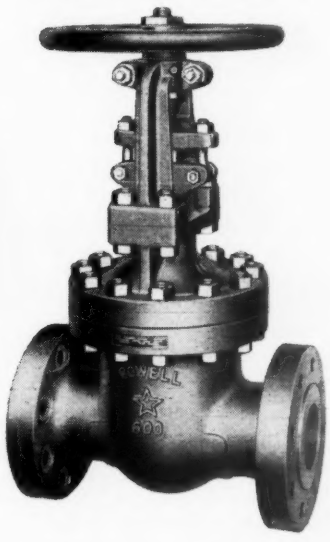


FIG. 6061 SS—600 Pound Stainless Steel Swing Check Valve

FIG. 6003 SS—Alloy Steel Gate Valve for 600 Pounds W.S.P.



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and alkylated phenylenediamines types are added to gasolines in the concentrations shown in Table 1.

The Military specify for all-purpose gasoline a minimum of 5 lb per 1000 bbl (active ingredient) of the following oxidation inhibitors, separately or in combination:

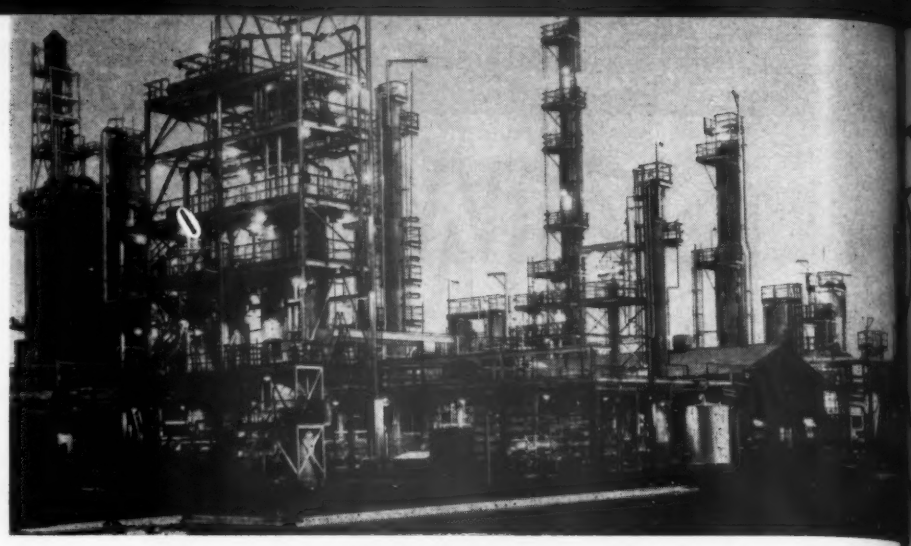
a. N, N′ Disecondary butyl-para-phenylenediamene (35 lb per 1000 bbl, max.)
b. N, n butyl-p-aminophenol (25 lb per 1000 bbl, max.)
c. N-iso-butyl-p-aminophenol (25 lb per 1000 bbl, max.)
d. Di-N, N′ sec-butyl-p-phenylenediamine (35 lb per 1000 bbl, max.)

Other Antioxidants—All-purpose gasoline may also contain antioxidants of the tri-alkyl phenol type in addition to the above types as a result of processing or standard inhibition practice of the refinery. The presence of addition of these other types of antioxidants does not waive the requirements of the above additives.

3. **Metal Deactivators**—Metal impurities, especially copper in amounts as little as ten parts per million can exert a catalytic effect on the oxidation of gasoline components. Brass fittings in automotive fuel systems can have the same effect. To improve the storage stability of gasolines containing such soluble metallo-organic compounds or soluble metal salts which act as metal catalysts, metal deactivators counteract the pro-oxidant effect of these contaminants. When so utilized they not only improve the stability of contaminated gasolines, but experience has indicated that in many cases it has been possible to reduce significantly the concentration of antioxidants necessary to achieve the desired oxidation stability. The Military state that all-purpose gasoline shall contain 1 lb per 1000 bbl of approved metal deactivator (active ingredient). Gasolines containing a copper-sweetened component shall contain additional metal deactivator, sufficient to neutralize the effect of possible residual copper, but not to exceed 3 lb per 1000 bbl. Metal deactivators N, N′ disalicyledene, 2 diaminopropane types are approved for this purpose.

4. **Antirust Additives for Gasolines**—Rust inhibitors are generally surface active agents which coat ferrous metals and prevent water-metal contact in pipe lines, storage tanks, or in vehicle fuel systems. Examples are ammonium sulfonates and organic phosphorous compounds. Some antirust additives inhibit corrosion of the die metal parts in the carburetor as well.

5. **Anti-icing**—Various alcohols in concentrations as high as two per cent are used as additives to prevent freezing of water in gasoline tanks, fuel pumps, strainer bowls, etc. They function as an antifreeze in the water present. Carburetor icing, whereby the engine stalls due to restrictions by ice formation on the throttle blade, can be prevented with such anti-icing agents.



Four-process combination distillation unit at the Mandan, North Dakota, refinery of Standard Oil (Indiana), where crude is "broken up" into its several components en route to becoming finished products.

6. **Pre-ignition Preventers**—The increase in the initial octane number requirement due to combustion chamber deposits is very critical in today's high compression passenger car engines. Both fuel and lubricants contribute to the octane requirement increase and resulting preignition problem. The leaded gasoline plays a role in that the lead salts formed during combustion catalyze the oxidation of carbon, creating glowing particles having sufficient temperature to ignite the fuel-air charge prematurely. Lubricating oil entering the combustion chamber also contributes because its decomposition products may form carbonaceous binders that cause the fuel deposits to adhere to the combustion chamber surfaces. Spark plug fouling also results. Various organic compounds of phosphorus are effective in reducing surface ignition. They minimize glow of combustion chamber deposits. As an additional effect, they combine with the lead from tetraethyl lead to prevent shorting of spark plugs. *Here is a problem to challenge the chemical and petroleum industry*. What is needed is an additive that will either prevent deposits or will modify them so they do not act as knock inducers.

7. **Upper Cylinder Lubricant**—Light lubricating oils added to gasoline are sometimes used as additives to help valve stem and upper cylinder lubrication. There is some evidence that they help to minimize intake valve deposits and reduce deposits causing preignition. Some applications are made through the air intake by removing the air cleaner. About 6 ounces at one time will help free valves and loosen piston rings if the engine has not been run in a stuck or frozen condition too long before treatment.

8. **Dyes and Decolorizers**—These are used to identify the various grades of gasoline such as regular, premium and aircraft.

Fuel Oils and Diesel Fuels

Middle Distillates—The middle distillate demand for 1955 is forecast at 686 million barrels or 6.5 per cent larger than 1954. To meet this rapidly expanding demand, it is necessary to increase the per barrel yield of middle distillate fuel. This increase goes hand-in-hand with the increased use of catalytic cracking whose end products are essentially high octane and middle distillate fuel. The introduction of cracked distillates has imparted the desirable characteristics of higher volumetric heat content and lower pour and cloud points, but has necessitated paying closer attention to the problems of stability and compatibility in storage and adequate ignition quality of diesel fuels. Table 2 tabulates the main middle distillate additives, dosage and volume.

TABLE 2. Estimated potential annual consumption of additives for middle distillate, fuel oil and diesel fuels—1955.

Kind	Dosage	Million pounds	Million dollars
Fuel Oil (antiscreen clogging and inhibitors of sediment and gum formation, anti-rust and anti-corrosion)...	20-35 lb./1000 bbl	12	4-6
Diesel fuel (cetane number improvers).....	0.1%-0.3%	1	0.3

1. **Anti-Screen Clogging Agents for Home Heating Fuel Oils and Diesel Fuel**—Distillate fuel oils tend to de-

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teriorate during long term storage resulting in the formation of soluble and insoluble residue. Closely related to the sediment problem is the phenomena known as incompatibility, wherein two fuels that are stable by themselves become instable in storage when blended. While soluble residue is not particularly harmful, insoluble residue causes screen filters of domestic oil burners and diesel engines to clog. The application of additives to middle distillate fuels is in its infancy. Such additives not only retard the formation of insoluble sludge and gum, but reduce the size of the particles by practically eliminating the possibility of clogging.

One type consists of soluble dispersing agents which control particle size and keep same in suspension. They also prevent water from binding the sediment to form impassible mats on oil burner screens. The second type combines dispersant properties with the ability to decrease the rate of formation of insoluble residue. Alkali and alkali earth sulfonates and certain non-ash containing materials are typical of those used for this purpose. Usually these additives also impart anti-rust and anti-corrosion protection to the middle distillate fuels. The ashless rust inhibitors are of the fatty acid type, however.

These distillate fuel oil additives make it possible for a refiner to blend catalytic cracked stock with a straight-run without sacrificing stability in the blend. The ashless ones are most suitable for use in blended fuels for diesel and jet engines.

2. **Cetane Number Improvers for Diesel Fuels**—The ignition quality of fuels used in diesel engines can be improved by adding small amounts of organic nitrogen oxides or peroxides. So far a blend of primary amyl nitrate is the best from a cost-effectiveness standpoint. As little as 1/10 to 3/10 per cent by volume of this new ignition improver will upgrade conventional heating oils into diesel fuel of acceptable cetane number and thereby simplify the refiner's or jobber's task of storing and meeting the relative demands for both products. Tests have shown that the *cetane numbers gained with amyl nitrate additives are equal to "natural" cetane numbers.*

Jet Fuels

A big jump in jet fuel demand is the principal change in petroleum requirements of the military forces for 1955. U. S. Military world-wide requirements for jet fuels on a peace time basis are estimated to be 65 million barrels; an increase of 36 per cent over 1954 volume. About 21 per cent of the makeup of the present jet fuel is kerosine, however, the proportion of kerosine in the the fuel will increase next year. The Capital Airlines will be using about 1½ million barrels of special kerosine in their jet-powered planes next year. This trend will increase as other airlines go to jets or their equivalent. Here again additives enter the picture, as metal deactivators and a special ashless antirust addition agent are specified by the Military.

Delayed coking unit at Duncan, Oklahoma, (Sunray) from which solid coke and cracked "middle distillate" are produced. These distillates require considerable quantities of additives to make them suitable for many purposes. This unit charges 9,000-bbl-per-day.

Residual Fuel Oils

Many residual boiler fuels are high in sludge-forming unsaturates and sulfur and sometimes the moisture content, especially salt water, is undesirably high. Sludging in storage and corrosion and slagging in boilers and gas turbines are problems met frequently when such fuels are used.

For some time sludge-dispersing, often termed dissolving, compounds have been offered. These are generally coal-tar-derived products, such as methyl and dimethylnaphthalenes. Some include surface active agents to emulsify water in the fuel oil to offset corrosion and rusting of the storage and dispensing equipment. This market has a potential of 6,000,000 gal of residual fuel additives or a value of 12 million dollars. The actual market is only a small fraction of this amount, however.

In operating modern high pressure-high temperature steam boilers in power plants and aboard ships, the slagging and corrosion of the superheat tube area has become a serious problem when burning residual fuels. The objectionable ash constituents are present in such small amounts and, in such chemical combination in the crude and fuel oils, that methods for their removal are difficult to apply on an economical commercial scale. While there is considerable controversy as to the mechanism of the slagging and deposit formation, the low fusing sodium and vanadium compounds seem to play an important part in the start of the formation and its subsequent build-up. The cost of maintaining a clean boiler has been decreased about ten-fold when

using dolomite as an additive. Also, the corrosive quality of the flue gases were reduced and the nuisance of fly ash decreased. Adding dolomite to the fuel oil is a regular operating procedure in some central stations. Aluminum and calcium oxide have also been used.

Heavy residuals have been tried in gas turbines with limited success. In railroad locomotives gas turbine operation, the lighter No. 6 grade, desalted to lower the sodium below 15 ppm and using an additive such as magnesium naphthenate, seems to be the best combination. This treatment reduces corrosion and deposits so as to make it possible to live with the gas turbine in locomotive road service. Blends of kaolin plus metallic additives into the residual fuels at 12 cents per barrel have been used succesfully in gas turbine locomotive operation in Europe.

Lubricant Additives — 1955

The overall 1955 demand for lubricating oils is estimated slightly in excess of 54 million barrels, of which 13.5 million barrels will be exported. Of the 41 million barrels to fill the domestic lubricating oil requirements, a little more than half this amount will be blended into motor oils, automotive gear lubricants and other oils for internal combustion engines, and the rest will be available for industrial lubricants, hydraulic oils, cutting oils and other general use products. Table 3 gives the listing of additives, dosage, and volume used, mostly in the manufacture of various automotive lubricating oils and lubricants.

TABLE 3. Estimated annual consumption of commercial additives mainly for automotive lubricants—1955.

Kind	Dosage	Million pounds	Million dollars
Detergents	2–10%	280/300	57
Antioxidants—corrosion inhibitors	0.4–2%	70/75	15
Viscosity index improvers	0.5–10%	60/65*	15
Pour point depressants	0.1–1%	5	2
Extreme pressure agents	5–10%	60**	14
Defoamants	0.0002–0.07%	.....	
Antirust agents	0.1–1%	.....	
Odor control	0.001–0.005%	.....	6
Oiliness imparters	0.1–1%	.....	
Fluorescent dyes		.....	

* Used also as pour depressant.
** 60% automotive and 40% industrial usage.

Motor Oil Additives

Motor oil inhibitor and detergency-dispersant additive levels for passenger cars, and light trucks are built around the API service classification recommended to meet some sort of standards based on motorist's driving conditions, whereas the military and certain buses and commercial truck accounts talk in terms of engine test combinations like the Standard L-4, 36-hour Chevrolet engine test for determining oxidation characteristics of an oil, and the Standard L-1 Caterpillar engine test to check detergency and wear, also alkaline reserve. The new CLR crankcase oil test engine is being correlated for the evaluation of the military lubricating oils to replace the L-4 and L-1 test engines, as they would no longer be available after 1956. The final adoption of this new CLR oil test engine might well clear up or change our concept of future motor oils and their additive nature and requirements.

Multi-Graded Motor Oils

Probably there has not been any other development in motor oils that has attracted such nation-wide interest, enthusiasm and controversy as the comparatively new multi-graded motor oils of the double SAE 10W and 20, and the triple viscosity SAE 10W-30 grades. Yet the 1955 models are now recommending them for use from —10 F to temperatures over 90 F. This meets the concept that there are two requirements to be considered in the selection of viscosity lubricating oils for automotive purposes; first, that the viscosity shall be suited to the working temperatures, and secondly, that it shall not be excessive at the starting temperatures. The multi-grade motor oils fulfill these requirements with one grade.

The wide variety of API service classification, most multi-grade motor oils meet the MS requirements, which are the most severe service conditions encountered in gasoline engines. However, some suppliers go to the DG level as it is felt that better cleanliness with lower wear control is obtained from this MS-DG type. Even though these triple graded 10W-30 motor oils of the MS-DG API service classification cost more, the advantages gained by their use are considerable, the most important being:

(1) easier starting in cold weather with less battery drag;
(2) reduced mechanical losses, with improved fuel economy and with more engine power available;
(3) lower oil bearing temperatures as a result of increased rate of oil circulation, provided that the oil pump has sufficient reserve capacity;
(4) better heat transfer so that air-cooling of the sump is more effective;
(5) reduction in carbon and lacquer, making for cleaner engines and less combustion chamber deposit that tend to raise octane requirements of the engine;
(6) better control of oil consumption under high temperature, hard driving, over longer periods of engine life;
(7) better lubrication in all seasons and in all climates;
(8) less wear on engine moving parts with greater extended periods of overhauls.

It is of real interest that there has appeared on the European Continent market, a 10W-SAE 40 quadruple, graded motor oil, equally effective in summer and winter, in all automotive engines, under all driving conditions. It also meets the API classification for ML, MM, MS, and also DG (for petrol engines). These latest multi-graded motor oils will run about 12 per cent of service station motor oil sales volume in 1955. They contain a total of 5 to 20 per cent of commercial additives. The additives used are in most cases a wider variety and are used in larger amounts, and are as follows:

1. **Viscosity Index Improvers**—The main aspect of oil quality which has been receiving the greatest commercial emphasis from industry has been cross-grading or the marked increase in viscosity index which permits one oil to span two or more SAE viscosity grades. Without VI improvers blended into the multigrade SAE 5W-20 or the SAE 10W-30 motor oils, it would not be possible to maintain viscosity high enough at high temperature (SAE 30) to give lubrication protection with low enough oil consumption and yet have viscosity low enough (SAE 10W) for easy starting at zero or below temperatures. These viscosity index improvers in general are long-chain polymers soluble in lubricating oils. The main chemical types are:

a. Polymers of methacrylic acid esters.
b. Polymerized butylenes.
c. Polymers of alkylated styrenes.

Viscosity index improvers when used to replace bright stock in multi-graded motor oils reduce combustion chamber deposits and resultant preignition. VI levels used for the multi-graded motor oils average about 7 per cent of the commercial additive. An important criterion of any viscosity index improver is its shear stability in engine operation so as to maintain a fair share of its original viscosity and viscosity index in use. The finished SAE 5W-20 motor oils are generally 150 VI, whereas the SAE 10W-30 run about 140 VI for cross-grading purposes.

2. **Pour Point Depressants**—The proper sub-zero pour point of the multi-graded motor oils and others used in low temperature operation is important. Even though the motor oil components are properly de-waxed the addition of pour point depressants is necessary to assure proper fluidity at low temperatures and only then can stable pour points be achieved by

The Author

C. M. "Cliff" Larson, chief consulting engineer, Sinclair Refining Company, is an outstanding authority on fuels and lubricants. His activities are world-wide and his work covers the entire range of these products. Mechanical engineering graduate of Armour Institute of Technology, he was employed as a lubrication engineer as a civilian and later as a first lieutenant in the Signal Corps, first World War, afterward joining Sinclair in charge of staff and lubrication engineers.

He is active in several oil industry societies, API, ASME, ASTM, IP (London), Institutes of Naval and of Aeronautical Engineers. He is the inventor of several instruments employed in his field, and has written many technical papers for various societies. He is headquartered in New York City.

proper dewaxing. Pour point depressants are also polymeric materials. Three common and widely used for this purpose are:

2. Wax-naphthalene condensation product and its polymers.
b. Wax-phenol condensation products and its polymers.
c. Polymer of a methacrylate ester.

Several of the viscosity index improvers when used in the amount necessary for cross-grading VI levels will give ASTM pour points of —25 F to —40 F in solvent refined Mid-Continent neutrals of 200 SUS at 100 F or lower viscosity so no addition of pour point depressant is necessary. These VI pour point depressants of high molecular weight polymers are also substituted for other pour point depressant types in amounts of 0.05 to 0.5 per cent and they give a boost of one or more VI as well.

3. **Detergents**—In order to meet the requirements of top quality motor oils in the API MS and/or DG Service Classification, a fairly heavy dosage of detergent additive is used to provide maximum engine cleanliness and low wear properties. These additives keep the oil oxidation products, as well as the products of fuel combustion that may get down into the crankcase, well dispersed. The deposition tendency of the engine sludge is reduced if the sludge is solubilized by the detergent. They should have little or no prooxidant effect.

Generally detergent additives are complex barium or calcium sulfonates or phenates as follows:

a. Sulfonates—From either petroleum or synthetic chemical sources, of the alkylaryl sulfonate type. These may be barium or calcium salts and they may be either neutral or highly alkaline in nature.
b. Phenol Compounds—Barium or calcium salts of alkylated phenols or alkylated phenol sulfides.
c. Polymers—Metal salts of P_2S_5 treated butylene polymers.
d. Nitrogen—Containing Polymeric—This new class of detergent is a copolymer or lauryl methacrylate and diethylaminoethyl methacrylate.

In recent years the trend has been toward the use of basic or alkaline type of sulfonates because of their stability to counteract acidic bodies which cause deposits and corrosive wear.

The latter class of synthetic nitrogen containing polymer is especially designed for use in "stop-and-go" passenger car service, API service classification MS. Being ashless in nature, they lessen combustion chamber deposits and preignition tendencies. They act as VI improvers and pour depressants as well.

4. **Antioxidants—Corrosion Inhibitors**—Motor oils are subject to oxidation if contacted with air or oxygen at elevated temperatures for sufficient long periods of time. Today it is not uncommon to find oil sump temperatures in excess of 250 F under certain types of engine operation. Oxidation and decomposition susceptibility of a crankcase oil doubles with 18 F rise in temperature. To improve lubricant stability and engine performance by reducing oil oxidation effects such as thickening, formation of corrosive acids, and varnish and sludge deposits, antioxidant inhibitors are used. These inhibitors stabilize oils against oxidation and inhibit alloy bearing corrosion. Additives that combat oxidation are usually complex organic chemical compounds containing phosphorous and sulfur. The major commercial types include:

a. Metal dialkyl dithiophosphates-Zinc dithiophosphate is now regarded as one of the better from a point of wear.
b. P_2S_5 treated terpenes.
c. Sulfurized terpenes or olefins.
d. Metal salts of phenol sulfides and their P_2S_5 reaction products.

In many instances the commercial additive is sold as an inhibitor-detergent combination and various percentages are blended with the particular base oil to satisfy the military or API service classification requirements based on dynamometer tests, and/or on fleet tests.

5. **Anti-Foam Agents**—Foaming of crankcase oil is brought about by being continually aerated as it is circulated in the engine. With the wider use of detergent oils the problem of foaming increased and tight foams resulted. Loss of the crankcase oil through the breather was the result. Silicone oils were found to be exceedingly effective. Usually a few parts per million check the foaming. In most commercial detergent-inhibitor additives, the antifoam agent has been added in proper proportions so that when the commercial package additive is added, the finished blend is automatically at the right antifoam level.

6. **Antirust Agents**—Rust preventers are used in crankcase preservative oils and in some automotive factory-fills of engine crankcase. The compounds, polar in nature, are metallic soaps, esters, ethers, and derivatives of dibasic acids. They have not been used widely in service station oils, however, some barium and calcium sulfonates used as detergents also impart rust inhibiting characteristics and are able to pass the hydrobromic, salt water immersion and humidity cabinet requirements of MIL-L-21260 when used in sufficient quantity to give a good order of detergency under MIL-L-2104A type approval.

7. **Oiliness Imparters**—The "oiliness" of a lubricant is still the most fugitive and difficult quality of the lubricant to evaluate. Oiliness sometimes referred to as lubricity, is defined as smoothness or slipperiness, and these materials function by decreasing friction. The types of compounds which give the best evidence of imparting oiliness seem to contain oxygen as in soaps and esters of fatty acids; soaps of sulfuric acids; and esters of phosphorous and phosphoric acids. Sulfurized sperm oil is sometimes used. Fatty acid, as oleic, was one of the first used in motor oils but the high rate of corrosion of alloy bearings made it necessary to drop same.

8. **Fluorescent Dyes**—These are used to darken the oils and give them a very pleasing caste. They are added in small amounts, sometimes as much as 0.25 per cent.

9. **Odor Control**—These are masking agents that cover up the characteristic odor of the various additive components in the motor oils and gear lubricants. About 2.4 grams per bbl does the trick. They are weighed out and added by hand, as in the case with antifoam agents.

Automatic Transmission Fluid, Type A

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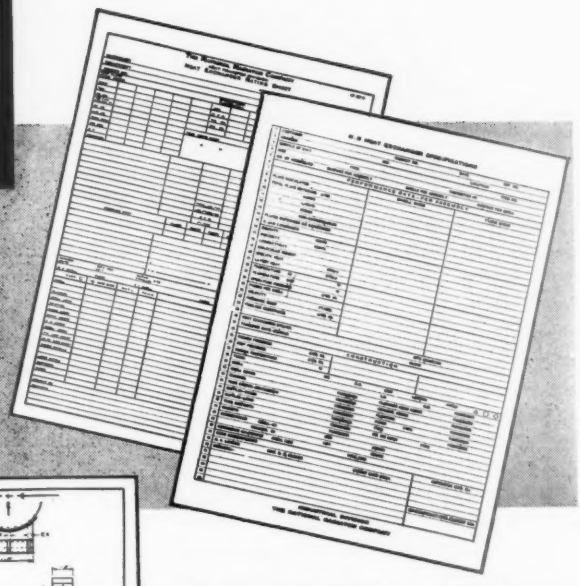

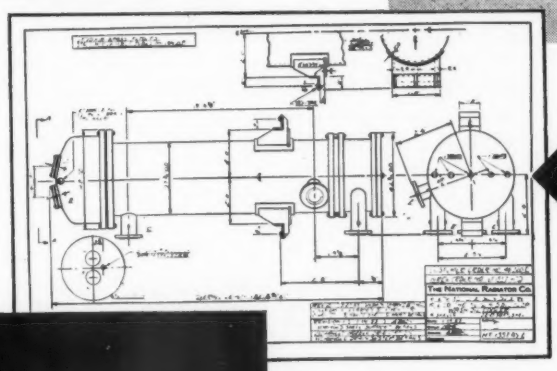

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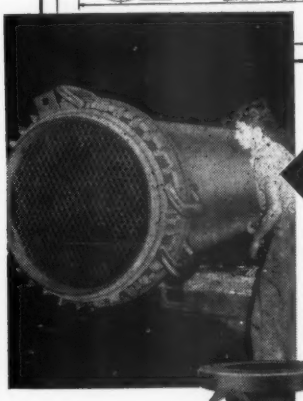

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automatic transmission fluid, Type A. This highly engineered, qualified and approved product is used and recommended by passenger car manufacturers for all makes of automatic transmissions—summer and winter. It is also replacing the SAE 10W and 20W motor oils formerly recommended for some conventional type transmissions. Its use for power steering systems is also becoming universal. Protection against rust and corrosion, resistance to oxidation and the formation of harmful lacquers, gum and sludge, resistance to foaming, excellent lubrication of metal parts and a high viscosity index are only the start before a long journey of performance and machine element testing before the product is qualified and approved for use by the passenger car manufacturers and for service station dispensing purposes. Thus complete protection of the units and smoother full power transmission performance is assured.

These General Motors Corporation's approved Type A products contain fair amounts of detergents, inhibitor, oiliness agent, pour depressant, viscosity index improver, and antifoam additives.

Multipurpose Type Gear Lubricants

Although there are four API designations of automotive gear lubricants referred to in the SAE Handbook, the present car instruction books, representing 95 per cent of the total car sales, have adopted the API term "multipurpose" gear lubricant.

In general, two SAE viscosity grades are called for namely, SAE 90 or 80. Both are listed for the same model in summer by some car manufacturers. Thus, it is logical to have a double graded SAE 80-90 multipurpose-type gear lubricant, which answers all conventional transmission requirements other than where automatic transmission fluid, Type A, is recommended, as well as for spiral-bevel and hypoid type differentials of passenger cars and trucks.

Multipurpose gear lubricants for the above coverage should have the highest possible load carrying capacity to meet the performance level of high speed and torque. Typical of such gears are the hypoid type used in passenger cars and trucks. Such superior, multipurpose, all season, gear lubricants of extreme pressure, anti-rust, anti-corrosive, anti-oxidation, anti-foaming type with a low pour and sub-zero channel characteristics, can be used to replace other API regular-type, mild-type EP gear lubricant type designations, offering economical logistics of application through one service station dispenser and freedom from misapplication.

The EP additives used in these MIL-L-2105 military approvals, will analyze chlorine 17 to 31 per cent, phosphorous 0 to 1.2 per cent and sulfur 6.8 to 11 per cent. These are usually added in 5 to 10 per cent depending on their relative chemical structure. The shear rate of hypoid gears is very high, so that VI improvers to meet the dual branded SAE 80-90 viscosity gear lubricant requirements are not generally recommended.

For automotive factory-fill of rear axles, the lead active sulfur gear lubricants are used to help lap in the hypoid gears, also they are lower in price.

Automotive Multipurpose Grease

The SAE General Information Report in the SAE Handbook, under the heading of "Automotive Lubricating Greases," states that "one of the most important phases of preventive maintenance of the modern automobile is the lubrication of the various components with suitable lubricants at the proper intervals—." There are at least seven automotive greases designated, but only one is a multipurpose-type grease. This term designates lubricating greases of such character, structure, and consistency as intended to meet the individual requirements for chassis lubricant, wheel-bearing lubricant, universal-joint lubricant, water-pump lubricant, and cup grease, as described in the SAE Handbook.

These multipurpose greases for general car application were made possible by the development of new metal soaps, such as lithium, and technical advances in grease-making. Although they are higher in cost than the limited purpose greases they replace, they have a marked service performance advantage and simplify dealer equipment storage and lubrication problems. Such multipurpose greases have to meet laboratory evaluation including a severe wheel bearing test and then extensive field evaluation tests on passenger cars and trucks, and, in some instances, on buses as well. Such superior quality greases have excellent water resistance, high temperature resistance and rust prevention; are easier to pump and handle at low temperatures and demonstrate outstanding stability and staying properties in service over longer periods and a wide variety of operating conditions.

These greases use a high quality antioxidant to stabilize them. These grease inhibitors are highly effective as a metal deactivator as well as an antioxidant. Usually the metal soap acts as rust inhibitor, a property which is needed in the successful multipurpose-type grease.

Industrial Oils and Lubricants

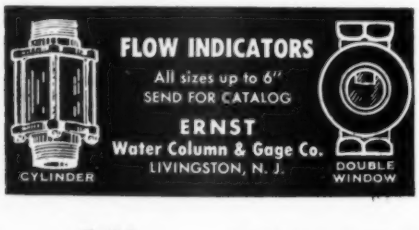
Many industrial oils are fortified with additives to meet a wide variety of service conditions. In this connection, it should be emphasized that the use of additives or inhibitors does not transform a poor quality base oil into a high quality product, although some improvement can be effected in this manner. It is important that the base oil used must be of high quality. Some of the most commonly used additives are similar to those used in the automotive classifications, but the activity of some is designed for lower temperatures, such as in the case of antioxidants for turbine oils that operate below 150 F. Usually substituted phenols or aromatic amines are used in turbine and hydraulic oils to prevent formation of acids, sludges, and emulsions under conditions of relatively lower temperature operation. Table 4 gives a listing of the main lubricating oils common to industrial applications and the additives used in their formulation.

Cutting Fluids

The metal working industry will consume a little less than 60,000,000 gal of cutting fluids in 1955. Straight, ready-to-use cutting oils are the most popular.

TABLE 4. Industrial applications and their additive requirements.

Additives	Turbines	Hydraulics	Gear boxes: Worm	Gear boxes: Hypoid	Gear boxes: Other	General purpose no drip	Electric motor	Spindles Machine tools	Ways	Internal combustion engines	Steam engines and pumps	Circulating systems	Air compressors
Anti-rust	x	x		x	x		x	x		x		x	x
Anti-corrosion	x	x	x	x	x		x	x	x	x	x	x	x
Anti-oxidant	x	x					x			x		x	
Pour depressant		x	x	x	x		x			x			
Anti-foam	x	x	x	x	x		x	x		x		x	
Detergent										x			
Fatty oils			x								x		
Extreme pressure			x	x					x				
Tackiness						x							



A percentage breakdown of the types work out as follows:

Type	Percentage
Petroleum sulfonate water soluble oil	21%
Chemical emulsion water soluble	5%
Straight cutting oil (ready to use)	57%
Straight cutting bases (concentrated)	5%
Petroleum blending oil	12%
Total	100%

The types of chemicals or additives incorporated in the cutting fluids are indicated:

Insoluble oils	In cutting oils
Sulfonates	Fatty oils
Resin soaps	Sulfurized fatty oils
Mutual solvents	Sulfurized mineral oil
Germicides	Sulfochlorinated fatty mineral oil
Naphthenates	Sulfochlorinated mineral oil

Greases

Industrial greases are the next broad group. They are fundamentally an intimate dispersion of soap and oil, with or without certain additives to give oxidation stability, EP, controlled color, anti-rust and high temperature dropping point or low temperature low torque characteristics. The soap is of the chemical, fat, or fatty acid and an alkali. The choice of both the fat and the alkali contribute materially to the final properties of the grease. The alkali generally used, or metal component, for industrial greases are the soap of sodium, calcium, lithium, barium, aluminum, or lead fat. The fat may be animal, marine, or vegetable origin. A total of some 120,000,000 lb of fats will be used for all types of greases.

It is estimated that 60 per cent of the grease manufactured goes into automotive use. Mineral additives such as graphite, talc, asbestos, carbon black, mica, lead powder, and zinc powder are added for special types of applications. A new thickening agent, classed as a siliceous thickening agent, has appeared on the market. The one recommended is a substrate or sponge-like aggregate of extremely small particles of amorphous silica.

Synthetic Oils

Certain government service performance specifications for oils and greases are such that only synthetic lubricants are required. The major synthetics and the cost per gallon are listed in Table 5.

Outside of certain aircraft greases, the principal use of synthetic lubricants is for aircraft gas turbines where operating temperatures of bearings range from —65 to 450 F and gears to be lubricated from —65 to 400 F with medium to heavy loads and speeds up to 20,000 rpm. The diesters have shown the greatest promise for military jet engines and aircraft gas turbines. Compounded diesters (di-2-ethylexyl sebacate) were reported by NACA as being best for extremely high temperatures. Only graphite, however, provided effective lubrication at 1000 F in antifriction bearings, the ultimate temperatures of such bearings in future military jet engines.

TABLE 5. Choice of synthetic lubricants.

Product	Cost dollars per gallon
Diesters	$ 5—10
Silicones	$30—40
Silicate esters	$10—12
Polyglycol ethers	$ 2— 6
Phosphate esters	$ 4—12

The additive money volume for 1955 seems to be excellent. It appears that $150 million will be spent for lubricant additives, $100 million for automotive, and $50 million for industrial oils and greases. Surely this is a sizable sum, but yet how effective the service performance characteristics are when properly evaluated and applied.

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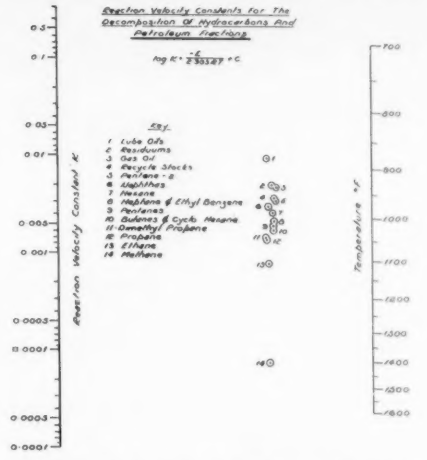

Hydrocarbon Cracking Rates

George E. Mapstone

The thermal cracking of hydrocarbons is a first order reaction with respect to the hydrocarbon or petroleum fraction if the decomposition is limited to less than 25 per cent conversion per pass. This may be written

$$K = \frac{1}{t} \ln \frac{a}{a - x} \quad . \quad . \quad (1)$$

Where:

K = reaction velocity constant
t = reaction time in seconds
a = percentage of material in feedstock (for pure hydrocarbon feedstocks a = 100)
x = percentage of material that decomposes during the time t.

The reaction velocity constant is related to the temperature thus

$$\ln K = \frac{-E}{RT} + C \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Where:

R = gas constant (1.985)
T = Absolute temperature, deg K.
E = energy of activation, cal per gm mol
C = constant

The relationships between the reaction velocity constant for a number of pure hydrocarbons and petroleum fractions shown by Nelson* are presented here in convenient nomographic form.

Because of the different feed and end products the term x in equation (1) has been defined different ways:

1. For the lubricating oil (point 1) the term x refers to the liquid volume percentage of lubricating oil produced by the decomposition.

2. For the petroleum cracking stocks (points 2, 4, 5, and 6) the term x is used as the liquid volume percentage of 400 F E.P. gasoline produced.

3. For the pure hydrocarbons (points 5, 7-14) term x is used as the mole percentage of feedstock hydrocarbon decomposed (or disappeared).

Reference

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NEW DEVELOPMENTS IN

Synthetic Elastomers

Four new synthetic elastomers the Acrylic elastomers, the Alfin polymers, Hypalon, and the polyester rubbers, (Vulkollan and Moltopren)—will play a major role in rubber industry's future development

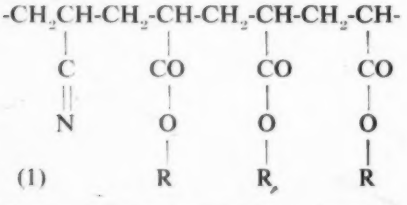
R. T. Woodhams and P. F. Bruins

THE synthetic rubber industry has grown enormously within the last decade. Recent developments are coming with tremendous strides. Today we are familiar with the original German development of Buna N followed by Buna S, GR-S, neoprene, butyl and polyvinyl chloride. Other well known polymers have found specialized uses: The polyisobutylenes, polyvinyl ethers, chlorinated polyethylene, and the Russian SKB. Although not all these elastomers are superior to natural rubber, they may have properties making them more suitable for specialized purposes. Thus, Buna N is particularly oil-resistant; Butyl has excellent age resistance and a low air porosity; Neoprene shows outstanding wear resistance, etc.

The following report briefly discusses four new, developmental stage, types of synthetic elastomers with a good future.

The Acrylic Elastomers

Copolymers of various acrylic esters (from ethyl to octyl) with 5 to 15 per cent acrylonitrile or methacrylonitrile have been prepared by the "Redox" or the refluxing emulsion method[1]. The structure of the polymer is represented schematically below. Formula (1):



(1)

These polymers were easily vulcanized with sulfur and amine activators, presumably by reaction with the reactive methylene groups.

Heat-resistant vulcanizates were obtained from the copolymers of acrylonitrile with ethyl, butyl, amyl, and hexyl acrylates and from the copolymer of methacrylonitrile with butyl acrylate. The octyl acrylate-acrylonitrile copolymers and the octyl acrylate, ethyl acrylate, and acrylonitrile terpolymers did not show similar heat resistance. Terpolymers obtained from ethyl acrylate, butyl acrylate, and acrylonitrile, however, produced heat-resistant vulcanizates.

The vulcanizates of lowest brittle points were obtained from the copolymers of the higher acrylic esters, but, regardless of the acrylic ester used, the brittle point was considerably increased with increasing acrylonitrile content of the copolymer. The butyl acrylate-methacrylonitrile copolymer appeared to have somewhat better heat-aging properties than the butyl acrylate-acrylonitrile copolymer.

Earlier investigations[2-6] resulted in the development of an acrylic elastomer (Lactoprene EV) that could be vulcanized to a rubber-like material with some unusual properties. This elastomer, a copolymer of 95 per cent ethyl acrylate and 5 per cent chloroethyl vinly ether, was vulcanizable with sulfur and organic amines, such as tetraethylene hexamine. The vulcanizates showed unusual resistance to heat and hot mineral oils as well as to atmospheric degradation and flexural breakdown. Commercial modifications known as Hycar PA-21 and Hycar PA-31 have become available.

More recently another acrylic elastomer, Lactoprene BN from B. F. Goodrich, a copolymer of butyl acrylate and acrylonitrile has appeared[9,10]; it has the desirable heat-resisting properties of Lactoprene EV, as well as improved low-temperature properties and better resistance to swelling by boiling water.

Ethyl acrylate, copolymerized with small amounts of acrylic or methacrylic acid, produces a polymer that is curable without the use of sulfur[11]. Curing of vulcanization is effected with metal oxides (ZnO, CaO, PbO, or MgO) which form salt bridges with the carboxyl groups. The new carboxylic elastomer shows tensile strengths as high as 10,000 psi without reinforcement. Films of this material, which are cast from the latex, show excellent abrasion and solvent resistance.

Hypalon

Hypalon, recently introduced to the rubber industry by E. I. duPont deNemours and Company[12-15], is made by treating polyethylene with chlorine and sulfur dioxide. The structure, and therefore the properties of chlorosulfonated polyethylene elastomers, can be varied by using different molecular weight polyethylenes and and various percentages of sulfur and chlorine.

The outstanding properties of Hypalon are complete resistance to abrasion, heat, sunlight, and weather. Blended with other elastomers, as with GR-S, butyl, Buna N, Hypalon has improved resistance to ozone.[16] It can be compounded and processed with conventional rubber machinery.

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be cured with a combination of metal oxides, sulfur-type accelerators, and organic acids; also with certain organic compounds in combination with acid acceptors. Since carbon black is not required in Hypalon, applications of this rubber-like material are independent of color.

The following are the most important commercial applications for Hypalon:

(a) Solution coatings, veneers and tank linings;

(b) Acid-resistant hose, electrical insulation, gaskets, pump housings, and impellers;

(c) Adhesives;

(d) Floor tiling.

Another of its uses now actively being investigated is for white sidewall tires. Its resistance to ozone cracking and discoloration makes it ideal for this purpose. Hypalon floor tiling became available during the latter part of 1954.

Alfin Rubbers

In 1944 A. A. Morton and co-workers found that a combination of allyl sodium, sodium isopropoxide and sodium chloride could convert butadiene into a high molecular weight polymer[17]. The use of sodium as an initiator for diene polymerization is not a new discovery. Mathews in England and Harries in Germany independently found that diene could be converted to a rubber in the presence of sodium more than 40 years ago. This process was used by Germany during the first World War for the preparation of methyl rubber from 2, 3-dimethyl butadiene and has been applied by the Russians to butadiene and butadiene and butadiene-styrene mixtures.

Unlike the ordinary sodium reagent, however, the mixed catalyst prepared by Morton and called an alfin catalyst, completely changed the nature of the polymerization. Five distinct features can be emphasized:

(1) The 1, 4 structure predominates instead of the usual 1, 2 structure for sodium-catalyzed polymerizations.

(2) The molecular weight appears to be independent of the monomer-catalyst ratio as well as the conversion.

(3) Extremely high molecular weights are obtained of the order of 10 million or greater.

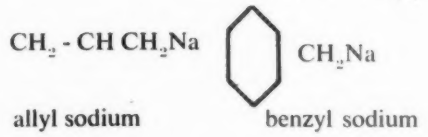
(4) The polymerization proceeds at a very high velocity. Almost complete conversion can be obtained in 30 minutes at room temperature.

(5) The process appears highly specific. Other metal salts and other monomers do not produce such an effective combination as the sodium alfin catalyst with butadiene.

Considerable research has been carried out using this triple salt combination which produces an exceptionally high molecular weight polymer.[18] The organo sodium component may be either allyl sodium or benzyl sodium.

Formula (2)

. . . (2)



allyl sodium benzyl sodium

The alkoxide is almost exclusively sodium isopropoxide, Na O $CH(CH_3)_2$. Sodium chloride has been the most successful halide salt used, although lithium, potassium, fluoride, and bromide salts have had various effects. Various monomers have been investigated, such as butadiene, styrene[19], isoprene [17], piperylene, 2, 3-dimethyl-butadiene[18], α and β-methyl styrene[19], and acrylonitrile[20]. Some efforts have been made to copolymerize styrene-butadiene[20] and the results indicate that that the styrene enters the chain in about the same proportion as in conveniental GR-S emulsion polymerization. Experiments have been carried out with various solvents[18] and associated organo sodium reagents[21-25].

Until recently alfin polymerization had been considered as ionic in nature, somewhat resembling the Ziegler reaction[26]. On the basis of experiments carried out by Morton and co-workers with radioactive carbon, it appears likely that the reaction is free radical in nature[18]. The catalyst is pictured as serving a threefold purpose: (a) It provides a surface upon which the molecules can be arranged in a regular array; (b) it permits the formation of a limited number of radicals; and (c) it prevents the termination of a growing radical until extremely high molecular weights have been obtained.

In order to obtain reproducible results, the alfin catalyst must be carefully prepared[27]. Butadiene is by far the most reactive monomer; 2, 3-dimethyl butadiene was not polymerized appreciably[28]. Acrylic esters and other monomers with functional groups react at the functional group instead of the vinyl bond[29, 30].

In general, the properties of the alfin polymers are those which might be expected of polymers of unusually high molecular weight. Breakdown of the polymer on a mill is difficult, since heat causes the formation of gel, an effect out of proportion to the extent of cross-linking due to the length of the chains. Copolymerization with styrene reduces the rate of polymerization as well as the intrinsic viscosity of the product. Tests have been made on this material[31, 32]. Polymerization can also be carried in the presence of oils.

When the material is compounded, tests show superior abrasion resistance, high flex life, and excellent aging properties as compared to "cold" rubber. The modulus is sightly higher than GR-S, but elongation at break is less.

The polymer has the interesting property of being set or vulcanized by heat without sulfur being present. Pressure and heat can be used to shape and set even the most intractible polybutadiene. Compounded poly-butadiene has better low temperature properties[32, 33, 34] and better resistance to aromatic hydrocarbons than Perbunan, but the resistance to aliphatic oils is not as good. The 75-25 copolymer is much better than GR-S and further development is being carried out. The alfin polymers have recently been produced on a continuous pilot plant scale at government laboratories in Akron, Ohio, and are being evaluated in tires and other products[35, 36, 37].

Polyester Rubbers

Considerable interest has been aroused in recent months with regard to the polyester rubber developed and marketed in Germany under the trade name of Vulkollan. Although still largely in the experimental stage, this new homogeneous synthetic rubber is regarded as one of the major achievements of the post-war era. Interest in this material was heightened with the announcement in March, 1954, that Goodyear Tire and Rubber Company had secured patents on a new polymer process similar to the production of German Vulkollan[38]. The new product is called Chemigum SL.

The synthesis of elastomeric materials from polyesters was begun in 1940 when P. Schlack observed that linear polyesters reacted with di-isocyanates and occasionally produced elastic products[39].

In 1942, H. Printen (Dynamit A. G. Troisdorf) found that by reacting di-isocyanates with polyesters containing trifunctional groups, valuable elastic materials could be formed[40].

From these investigations a new product called I Gummi was developed, a condensation of adipic acid, glycerol, and a glycol reacted with hexamethylene di-isocyanate. These materials had good elasticity but only slight tear resistance and they hardened during storage.

This work was taken up by Bayer and co-workers at Farbenwerke Bayer, Levergusen and since then a series of articles have appeared in the literature[41, 42].

The information available permits sub-division of the process into the following three stages:

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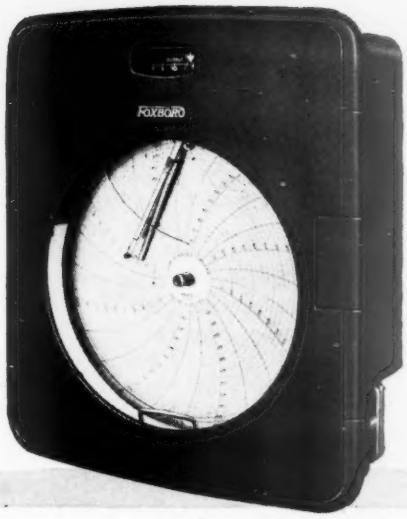

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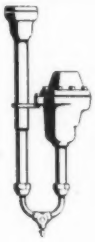	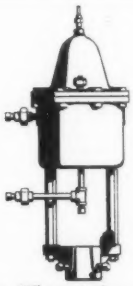	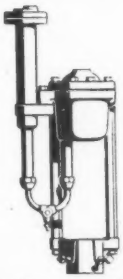	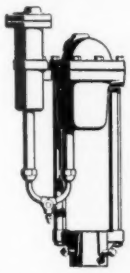	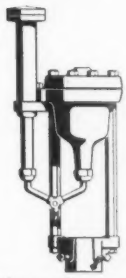
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(a) Preparation of the linear polyester.
(b) Branching of the polyester with di-isocyanate.
(c) Final cross-linking (curing) by addition of water, a glycol, a diamine, or additional isocyanate.

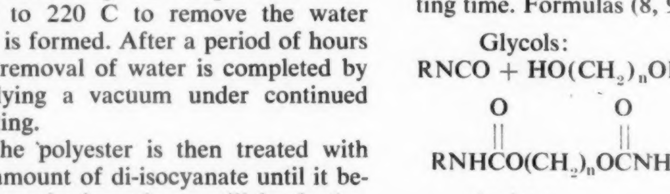
The polyesters are condensation products of dialcohols with dicarboxylic acids. Preferentially mentioned are the polyesters prepared from ethylene glycol and adipic acid and 1, 2 propylene glycol with adipic acid. Formula (3):

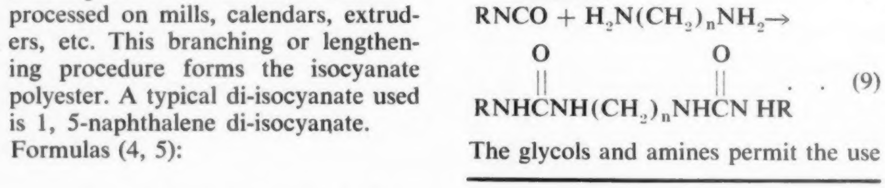
$$HOOC(CH_2)_4COOH \text{ (Adipic acid)} \left\{ \begin{array}{l} + HOCH_2CH_2OH \text{ (excess) Ethylene glycol} \\ + CH_3CHOHCH_2OH \text{ (excess) 1, 2-propylene glycol} \end{array} \right. \longrightarrow HO\text{-polyester-}OH \quad \ldots \quad (3)$$

The former appears to harden prematurely, but not the latter. In this respect the use of mixed glycols helps to combat the onset of crystallization in the finished polymer. Other functional groups can be built into the polyester, such as diamines, alcohol amines, and glycerol. The charge consists of an excess of the alcoholic components so that the end groups are all hydroxylic. This is the case for 13 moles of adipic acid to 14 moles glycol, yielding an average molecular weight of 2000-2500.

The polyester is prepared by melting together the two or more components and increasing the temperature from 160 to 220 C to remove the water that is formed. After a period of hours the removal of water is completed by applying a vacuum under continued heating.

The polyester is then treated with an amount of di-isocyanate until it becomes plastic and can still be further processed on mills, calendars, extruders, etc. This branching or lengthening procedure forms the isocyanate polyester. A typical di-isocyanate used is 1, 5-naphthalene di-isocyanate. Formulas (4, 5):





In the final stage the isocyanate polyester can be cured without the use of sulfur or accelerators. As a cross-linking agent water has been used, as well as glycols, amino alcohols (ethanolamine), diamines, and other bifunctional compounds. The reaction of water with an isocyanate produces a urea type compound and carbon dioxide. Formula (6):

$$2RNCO + H_2O \rightarrow RN\text{-}\overset{\overset{O}{\|}}{C}\text{-}NR + CO_2 \quad (\text{with H on each N}) \quad \ldots \quad (6)$$

The urea link will further react with isocyanate to give the cross-links. Formula (7):

$$RN\text{-}\overset{\overset{O}{\|}}{C}\text{-}NR + RNCO \rightarrow R\text{-}N\text{-}\overset{\overset{O}{\|}}{C}\text{-}N\text{-}R \text{ (with H on N; second N bearing } \underset{|}{CO}\text{-}NHR) \quad (7)$$

This reaction leads to a 3-dimensional network. Similar reactions occur with the glycols and amines which have the additional advantage of being less reactive and therefore delaying the setting time. Formulas (8, 9):

Glycols:

$$RNCO + HO(CH_2)_nOH \rightarrow RNH\overset{\overset{O}{\|}}{C}O(CH_2)_nO\overset{\overset{O}{\|}}{C}NHR \quad \ldots \quad (8)$$

Amines:

$$RNCO + H_2N(CH_2)_nNH_2 \rightarrow RNH\overset{\overset{O}{\|}}{C}NH(CH_2)_nNH\overset{\overset{O}{\|}}{C}N\,HR \quad \ldots \quad (9)$$

The glycols and amines permit the use of the liquid polyester which may be cured without pressure. Furthermore, no carbon dioxide is evolved, urethane bridges being formed with the glycols and double urea bridges with the diamines.

According to reports, German Vulcollan is being sold in the neighborhood of \$2.00 per lb, about 10 times the current price of GR-S, but its price will be cut to less than half when the polymer is manufactured on a full scale.

Outstanding properties of the polymer are its high abrasion resistance, good elasticity and good processing combined with oxidation and aging stability, non-swelling in oil and benzene, and very high tear resistance. Preparations made into heels show a wear superior to that of high styrene copolymers. The high abrasion and tear resistance is utilized in friction drives and in solid wheels for carts used under severe conditions as in steel mills and machine shops. The nonswelling property finds application in mechanical goods in refineries and in the chemical industry. The high aging resistance is due to the absence of unsaturated bonds in the polymer, a property in which both natural and GR-S rubber are deficient. This property of the Vulkollan-type polymers has been put to good use in tire sidewalls, foams, and sponges. The possibility of processing and curing in molds without pressure can also be considered among the desirable features.

Such favorable properties make it understandable why the Goodyear Tire and Rubber Company is already experimenting with the application of a polyester rubber in tire treadstocks[38]. It is equivalent to butyl rubber in air diffusion resistance; vulcanization times are cut in half. Since no carbon black is needed to reinforce the rubber, tires can be made of any desirable color.

It is interesting to note that the foamed polyester, called Moltopren, is already competing with natural rubber foams in several European countries. Moltopren can be produced by a slight modification of the procedure for making Vulkollan. A low molecular weight polyester is prepared with an excess of carboxyl end groups. The carboxyl groups react with di-isocyanates with the simultaneous chain lengthening, cross-linking and evolution of CO_2; see formula 10, 11, page C-60.

A final cross-linked, heat-resistant foam that can be produced in very resilient to rigid forms is obtained. The material is flame-retardant, impervious to oil and grease, resistant to oxidation, and has higher compression values and greater tensile strength than rubber.

These polyester foams are suitable for "foamed in place" applications.

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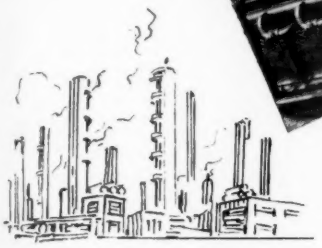
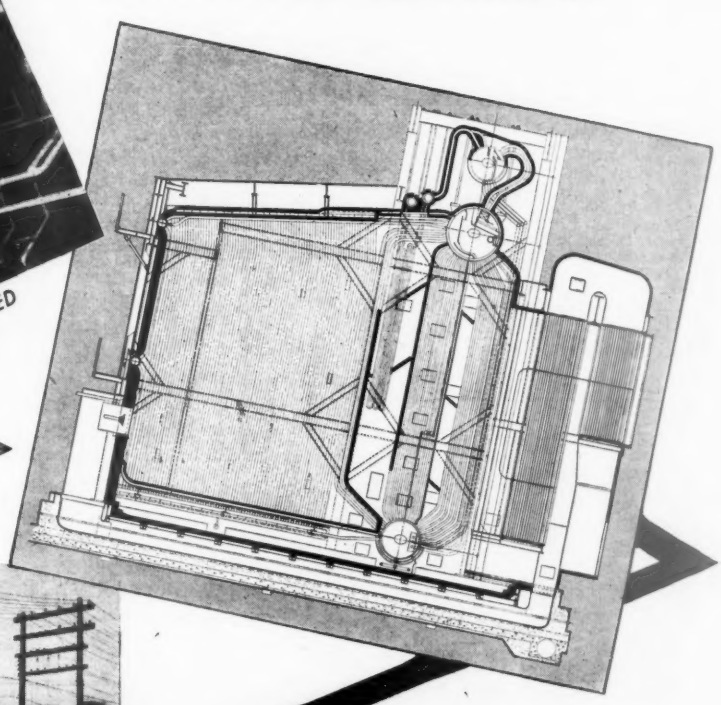
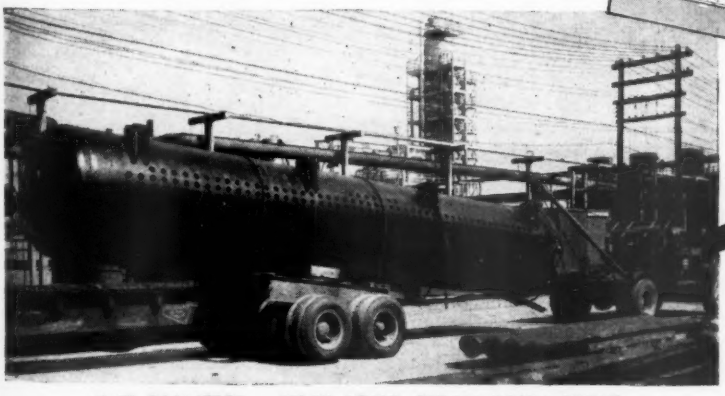


RIGHT →
LONGITUDINAL SECTION THROUGH THE UNIT.





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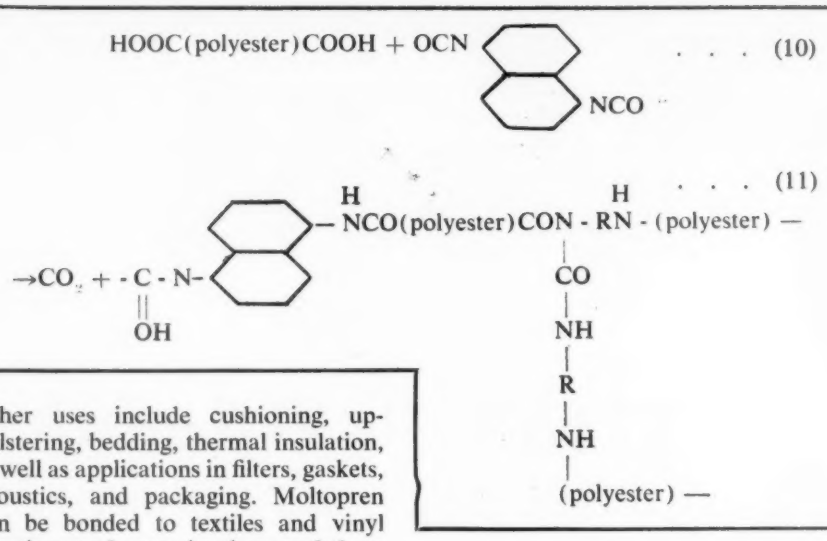

Other uses include cushioning, upholstering, bedding, thermal insulation, as well as applications in filters, gaskets, acoustics, and packaging. Moltopren can be bonded to textiles and vinyl sheeting and can be heat-sealed to other thermoplastic materials. The foam can be obtained in either open or closed cell form in thicknesses from ⅛ to 5 in.

Anticipating the demand for isocyanates, Monsanto and the Bayer Dye Works of Leverkusen have formed a separate company (Mobay) to supply the necessary di-isocyanates.

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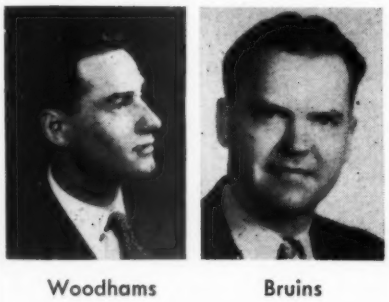
The Authors



Woodhams Bruins

Raymond T. Woodhams is with the newly-formed Dunlop Research Center, Toronto, Canada, working in the field of synthetic rubber. He is a member of the American Chemical Society and the Canadian Institute of Chemistry. He received his BS and MS from the University of Western Ontario, and Ph.D. from the Polytechnic Institute of Brooklyn, New York. Woodhams' dissertation was carried out on polymerization kinetics.

Paul F. Bruins, professor of chemical engineering at Polytechnic Institute of Brooklyn, is also a consultant in the field of technology of resins and plastics. He received his Ph.D. at Iowa State College, where his research concerned the utilization of furfural in rubber and plastics. He is a member of the American Chemical Society and the American Institute of Chemical Engineers.

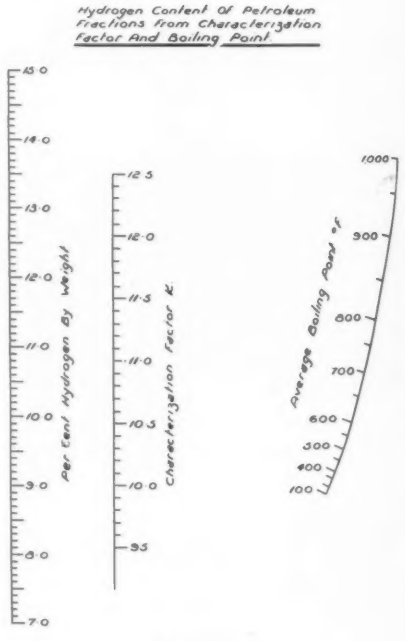
PLANT AIDS

Hydrogen Content of Petroleum Fractions

George E. Mapstone

The hydrogen content of petroleum fractions varies with the hydrocarbon types present and also with the boiling point. The UOP characterization factor, K, provides a measure of the composition of the oil and can be related to the average boiling point and hydrogen content of the fraction*. This nomograph has been designed to allow the simple and direct estimation of the hydrogen content of petroleum fractions from their average boiling points and their UOP characterization factors. It provides a simpler and more precise method of determining the relationship than does the original data*.

Example: A sample has average boiling point 750 F and K = 11. What is its hydrogen centent? Connect 750 on the temperature (right hand) scale with 11.0 on the K (center) scale and extend to give 10.7 per cent hydrogen from the left hand scale. The sample therefore contains 10.7 per cent of hydrogen by weight.


Hydrogen Content Of Petroleum Fractions from Characterization Factor And Boiling Point
Per Cent Hydrogen By Weight
Characterization Factor K
Average Boiling Point °F

Reference

*Hougen, O. A., and Watson, K. M. *Chemical Process Principles*, J. Wiley and Sons, New York, 1943, pp. 333-4.

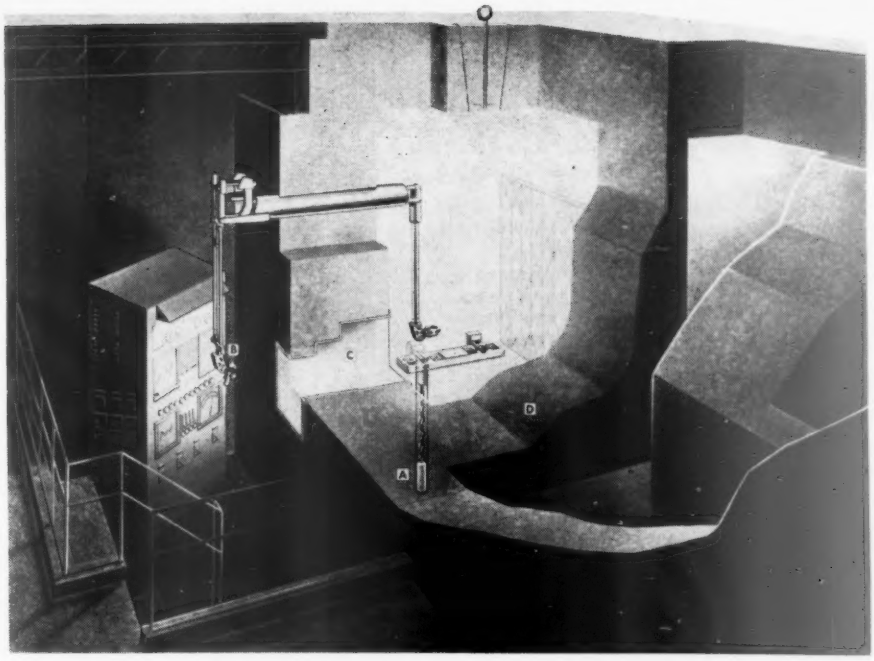


FIG. 1. "Cave" in radiation lab is protected (D) with thick walls. A: bottom of storage well for radioactive pipe. B: One of two mechanical hands to handle pipe and chemicals. (C) lead-glass window.

ATOMIC ENERGY

Enters Refining Field

Gamma ray experiment center will seek secrets for oil and chemical reactions

Eugene B. Brien*

STANDARD Oil Development Company is entering into a long-range research program in the use of atomic energy to find new and better products as well as processes for producing gasoline, motor oils, lubricants, and petrochemicals, E. V. Murphree, president, stated in announcing the construction of a radiation laboratory to be completed next April, at Linden, New Jersey.

The new facilities (Fig. 1) at the Esso Research Center are the first privately financed radiation leboratories of this magnitude in the world's petroleum industry, he added. The laboratory will cost one-quarter million dollars, employ about six scientists, and require another million dollars in the next 4 to 5 years, it was said.

*Eastern Editor.

EXCLUSIVE

Purpose of the atomic research effort is to find a new application for the vast energy in atoms. The center will attempt to influence chemical reactions now achieved through temperature, pressures, time, and catalyst and to find out exactly what atomic radiation can do. Although results are unknown, and perhaps even unsuspected, it is hoped that many reactions of basic interest to petroleum chemistry can be discovered.

Source of the atomic energy to be used is a 13 in. by 2 in. radioactive cobalt pipe (Fig. 2) clad with aluminum (to prevent scratches in handling and dissipation of radioactivity) and valued at $17,000. The cobalt radiates gamma rays which will be the only atomic tool for investigation. For the past two and a half years, the pipe has been undergoing neutron bombardment in the atomic pile at Brookhaven, Long Island.

Three types of rays are well known: alpha, beta, and gamma. The first two are weak and have a short half-life, but gamma rays are sufficiently potent to penetrate a one-half-in. lead shield; gamma rays will be utilized at the Linden laboratory. This S.O.D. pipe has a rated strength of 3500-4000 curies (about 10 billion times more reactive than a luminous wristwatch dial) and has a half-life of 5 years. No other single piece of cobalt in the world is as strong. In terms of radium, it is almost twice as powerful as the total world supply of refined radium. The pipe was made radioactive at the Brookhaven National Laboratory, Upton, Long Island.

The petroleum scientists under the direction of Dr. James F. Black will concentrate mainly, at first, on exploratory work, as the entire field of atomic energy in petroleum and petrochemical process is virgin territory. As they learn more about the effects of gamma rays—perhaps the cracking of petroleum can be achieved without the use of high heat or catalyst, Murphree reported—Esso plans to pursue its work to the small pilot plant stage.

The line of research the company

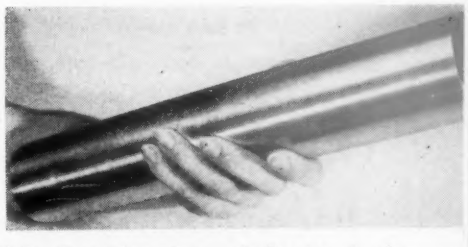


FIG. 2. Radioactive cobalt pipe is the essential tool to be used for irradiating petroleum fractions in Research Center.

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FIG. 21—Lip Mold

FIG. 22—Standard

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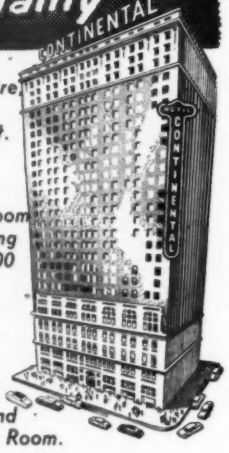

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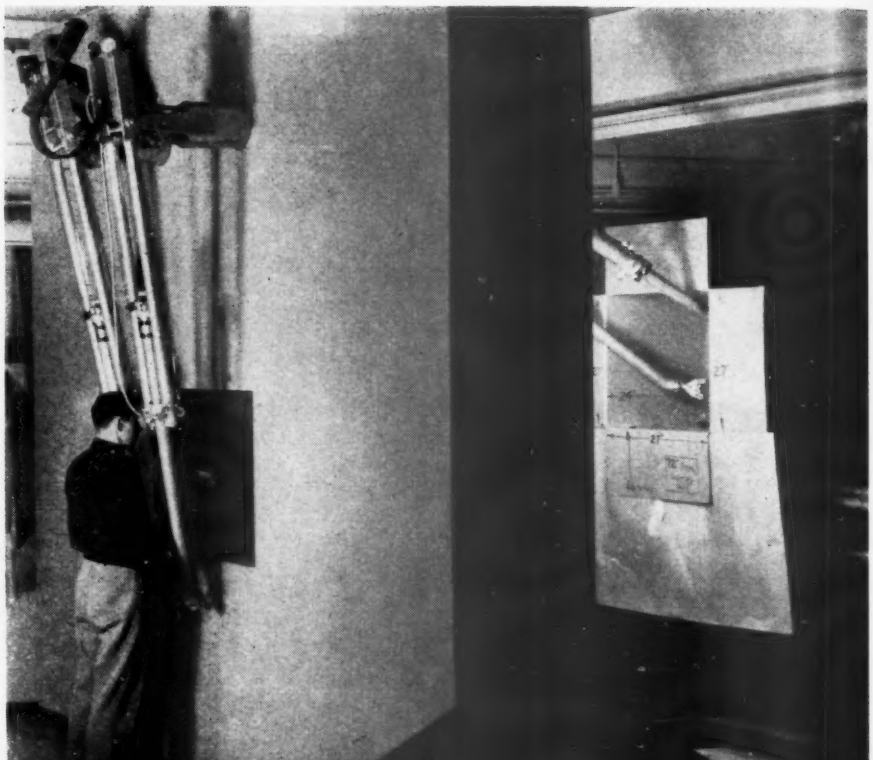


FIG. 3. Mechanical hands will be used to manipulate pipe and specimens in first non-government atomic research laboratory.

plans to follow is to apply atomic energy directly in processes without first converting the radiation into heat or other form of power. Use of atomic energy for heat or power is still far too expensive, Murphree estimated, to be competitive with traditional sources of energy. Atomic industrialization must wait 10 to 20 years for a supply sufficiently inexpensive for large-scale, industrial application.

It is already well known that polymerization can take place under radiation and that some polymers have taken on new charactertistics after radiation. General Electric in the past year irradiated polyethylene and substantially increased that polymer's resistance to heat and chemical reaction: In 350 F temperature, it resisted cracking. Source of the radiation in this commercial product was cathode rays from an electron generator.

Experiments at the new radiation laboratory will take place in the "cave," a 6 ft by 9 ft room heavily shielded with 4-ft concrete walls and roof. Scientists will peer inside the room through a 3-ft window and conduct experiments by means of mechanical hands (Fig. 3). Specimens to be worked can be placed in the cave manually, or can be put in or removed by a track not too dissimilar from that of a toy train. When irradiation is to take place, an operator will lift the cobalt source out of a sealed well in the floor of the cave, place it near the petroleum fraction or other chemical in order to radiate it under various conditions. The cobalt pipe will then be returned to its well and covered by a thick lead cover.

The room, the equipment or the specimen does not become radioactive by exposure, it was said, no more so than an X-rayed tooth remains affected. Actually, gamma rays are much like light rays: Their strength varies inversely with the square of the distance and they stop as soon as their source is removed—or the light bulb turned off. Workers can enter the cave in complete safety after the cobalt has been sealed in its well. Small specimens can be placed inside the 2-in. pipe for other experiments.

In this manner, Esso scientists will make a broad investigation of radiation to promote chemical reactions that may prove of outstanding interest to the petroleum industry.

S.O.D. has had a relatively long experience in atomic energy going back to 1938. Murphree is a member of the Atomic Energy Commission's general advisory committee and was on the Manhattan Project. For the past two years, company scientists have been using the Brookhaven National Laboratory facilities where they have been acquiring operating experience in radiation. * * *

FIELD KIT for Determining "Per Cent Spent" of Caustic Wash

Maxey Brooke*

FREQUENTLY, refinery operators wish to know how far spent is the caustic in their washers. The alternatives are usually (1) send a sample of the caustic to the laboratory for analysis or (2) keep a set of somewhat fragile volumetric equipment at the unit. Although both methods are good, a rugged simple field kit is frequently desirable. Such a kit has been designed which requires no carefully standardized solutions and no volumetric glass ware other than an ordinary medicine dropper. Although the results may be somewhat high due to interfering compounds, they will be consistent for a washer on any one product stream; thus, providing a valuable control point

for the washer's operation. Contents of the kit shown above are:

1. One ounce dropper bottle of phenolphthalein solution — approximately 1 gram phenolphthalein dissolved in 1 liter denatured ethyl alcohol.

2. One ounce dropper bottle of mixed indicator solution—one gram brom cresol green and 5 grams methyl red dissolved in 1 liter isopropyl alcohol.

3. Four ounce bottle of approximately 10 per cent hydrochloric acid —one part concentrated hydrochloric acid to two parts distilled water.

4. Fifty ml. erlenmeyer flask.

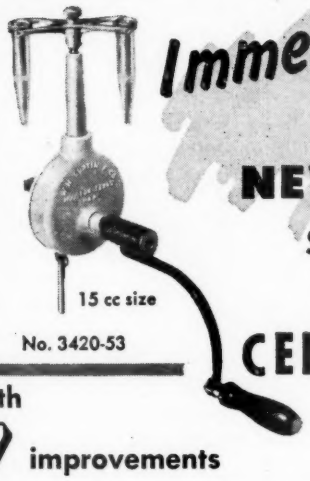
5. Medicine dropper.

Test procedure is: Add a dropper full of the caustic to be tested to the erlenmeyer flask. The volume is not critical. The caustic can be diluted with distilled water if desired. Add one drop of phenolphthalein. Add hydrochloric acid drop-wise, counting the drops. Swirl the flask after each addition until the red color fades. Record the number of drops as P. Add one drop of mixed indicator. Continue adding the hydrochloric acid, counting the drops and swirling the flask until the pink color changes to blue. Record the total number of drops *from the start of the test as* M.

The per cent spent can then be calculated from the formula:

$$\% \text{ Spent} = \frac{200\,(M - P)}{M}$$

*Maxey Brooke, Phillips Petroleum Company, Sweeny, Texas.



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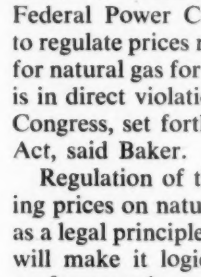
R. N. Dyer, Humble Oil & Refining Company's head of personnel division, discussed problems of selecting and directing new engineer employees.

H. N. Frost, technical foreman, Pure Oil Company, Smith's Bluff Refinery, presided over technical sessions.

C. A. Murray, Pure Oil Company, showed in a practical way how an inhibitor was used to minimize both fouling and corrosion in refinery equipment.

Industrial Relations Manager L. B. Gough, Magnolia Petroleum Company, presided over employee relations sessions.



H. R. Lyles, Cities Service Refining Corporation, showed how to operate a naphtha treater to reduce troubles.

R. W. Hurn, U. S. Bureau of Mines, spoke on the subject, "New Combustion Bomb."

Betterment of employee relations to obtain more satisfactory results was the theme of the paper by D. M. Clark, Phillips Petroleum Company.

C. L. Stinnett, Personnel Association of Arkansas president, was able to show progress in combatting abuses of group insurance in that state's industries.

Wm. A. Boles, The Lunkenheimer Company, gave data on the selection and servicing of valves and their trims for different refinery and chemical plant services.

THE decision of the U. S. Supreme Court in the Phillips gas-price suit has already brought chaos to the gas-producing industry and has lessened the incentive to look for more gas, Humble Oil & Refining general counsel and vice president Rex G. Baker told the Western Petroleum Refiners at Beaumont, Texas, at their February, 1955, meet. This decision that granted to the Federal Power Commission authority to regulate prices received by producers for natural gas for interstate commerce, is in direct violation of the purpose of Congress, set forth in the Natural Gas Act, said Baker.

Regulation of the producers' receiving prices on natural gas, if established as a legal principle in our national laws, will make it logical to control prices on farm products, manufactured goods of all kinds, and on any products or materials shipped in interstate commerce, this speaker stated. Agreeing that distribution of gas to consumers and its transmission through interstate pipe lines are utility functions and are properly regulated, Baker pointed out the primary difference between this operation and that of gas producers: Utilities are protected from competition, and thus must be regulated by law to prevent abuses. Gas production is not protected from competition and thus is regulated by that best of all controls, competition, free enterprise. The Court in rendering this decision challenges the fundamental principle on which free enterprise is based; the result will be that both producer and consumer will suffer from this price-fixing by governmental ukase, Baker indicated.

Problems dealing with personnel are coming rapidly to be one of the two or three major fields of study and research for management, so indicated D. M. Clark, Phillips Petroleum Company. Causes for many of the difficulties involved in lowered production in any operation may be looked for and often found traceable to human factors; willingness and ability are the two important factors in efficiency on any given job, Clark said. Nowadays medical examinations are among the important early considerations in the study of a new applicant; the ancient rule of seniority may easily and frequently put the wrong man in any job; the right man in the right job is the first step toward good performance. The amount of new information learned by a man on a job determines how he grows, how well the job gets done. Job training is coming to be considered more and more important for good overall results. Job and organization morale are great influences in elimination of accident hazards and affect largely the employee's willingness to work satisfactorily. Rewards, bonuses, credit for good performance, all these improve measurably the employees' picture. Additionally of far-reaching importance is the consideration of general educational training in such things as economics of the company and its financial position and prospects, details of the company's business. The employee wishes to feel that he "belongs"; that the company is strong and sound, financially and in its business prospects, that he has a chance for advancement.

Go Hunting for Engineer Talent

Company executives and "talent scouts" cannot sit at a desk and obtain the kind of engineering brains and

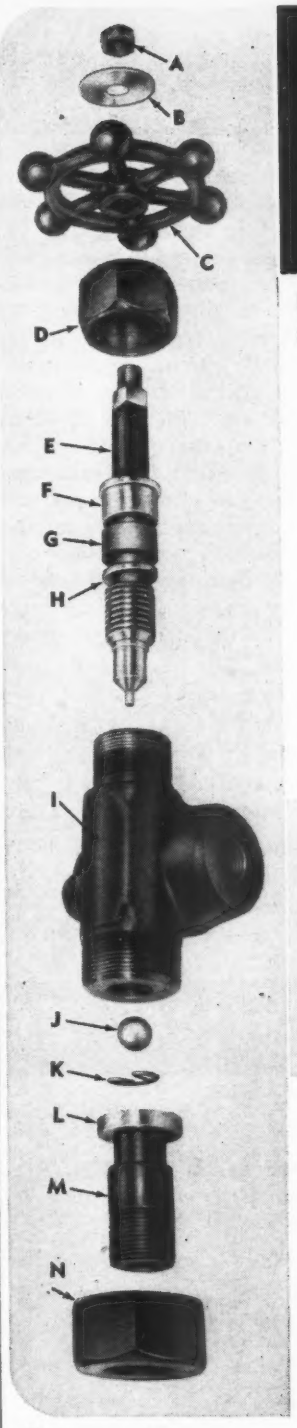
capabilities the company needs, says Humble Personnel Head R. N. Dyer. The professional man, that is the engineer, must be placed in his professional field; sub-professional work must be assigned to personnel of sub-professional training. We are approaching slowly the saturation or levelling-off point in our graduate engineer "crop"; we anticipate 30,000 bachelor graduates in 1955, 34,000 in 1956. Yet the search for new graduate employee material is a tough one, Dyer indicates. Massachusetts Institute of Technology was visited by men from 800 companies in one recent year, 50 more than the number of graduates. Nor must the men who go looking for promising new graduates be "small caliber," the speaker implied; they must know the company's policy in employing personnel. Humble obligates the company to reply to every application received, whatever the decision may be in each case. Nor does the company pay travel expenses of a new hand when reporting from home or school to the job; after that, all moves required by the company are at company expense. Initial travel is being paid by companies on our west coast, reports say.

New engineers are interested not only in the mere salary offered; they also want to know the prospects as to hospitalization, the chances for personal advancement, schools, churches, the geographical location of the job, the company's financial history and status, opportunities for participation in professional societies, training programs, and especially in being placed properly in the right job.

Four basic fundamentals govern the matter of engineer employment:

1. The right to religious freedom;
2. The right to study and to make advancement;
3. To work under conditions of his choice and preference;
4. The right to the exercise and realization of the foregoing rights.

"No square pegs in round holes" is a working fundamental in managing engineer personnel. Men need to know they are "important"; need to know that demonstrated ability gets promotions. Pressure or engineering service is greater now than ever before, pressure on the engineering profession is increasing because of our going further into greater new fields of technological development, said Dyer. Statistics, unfortunately, show that interest among college students in fundamentals of engineering is appreciably less than it was 25 years ago, he added.



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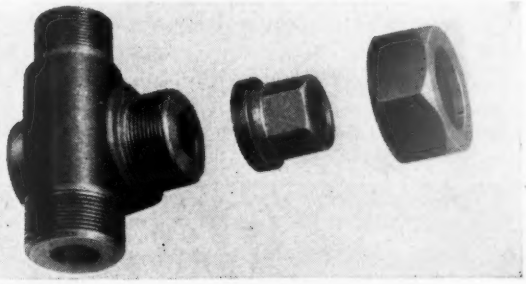

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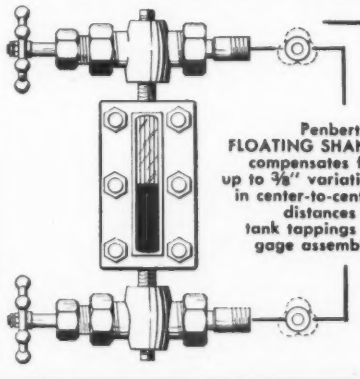

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Insurance Costs Mounting

Mounting costs in hospitalization and sickness insurance, many of them traceable to abuses of the system, are posing a bothersome problem to refinery insurance, personnel and other executives, reported C. L. Stinnett of the Personnel Association of Arkansas. Seventy per cent of all hospital income is said to be derived from hospitalization insurance; insurance held by the patient is no excuse for upping the charges against that patient. If we cannot stop the trend toward higher insurance costs, the people who pay the bill will react against the whole plan, and in the last analysis this points to socialized medicine, a situation most undesirable to oil companies, doctors and insurance companies alike. In fact the speaker's implications were that only professional do-gooders want socialized medicine, of which class we have a great number in this country. These many abuses are being attacked by the Arkansas Association, in many cases with considerable success, especially over-charging the insurance companies, giving of medical service when not required; giving medical treatment or laboratory or clinical treatment or services that are not indicated. Some apparent chicanery on the part of some medical men has been found, Stinnett said. He added that in many cases the patient puts strong pressure on his family doctor to approve a given charge "Or I'll go to a doctor who *will* approve it."

Technical Advances Reported

A special bomb for the study of the ignition properties of fuels has been developed by the Bureau of Mines at Bartlesville Station, and throws a great deal of light on these properties, says R. W. Hurn of that station staff. A single injector forces a single jet of fuel into the stainless steel bomb, charged with air, and it can be operated up to 1400 F and with wide range of fuel-air mixture compositions. Three factors affect fuel burning: Time, mixture ratio, and fuel composition. Fuels of different compositions show varying burning properties; some show quiescence until burning starts almost instantly; other show preliminary burning leading to the main combustion cycle or "burn."

Details of operation of a new Unisol stripper unit at the Cities Service Lake Charles refinery were discussed by H. R. Lyles of that company's technical staff. Methanol of 95 per cent purity is diluted to 20 per cent to "break out" the mercaptan recovered from naphthas, the mercaptans are separated and sent to the crackers, (who do not want them), and the methanol reconcentrated by distillation. Caustic is regenerated in a 9-ft tower filled with Raschig rings in which monel is the best alloy. Details of methods and changes in methods were extensive and of major interest to the operator of such units. Eventually Raschig rings were dispensed with, and bubble trays installed, giving a clear caustic regenerate that formerly was "muddy."

For the prevention of fouling as well as of corrosion, the injection of a (proprietary) inhibitor—not named—show neither corrosion nor appreciable fouling in more than a year, where before cleaning and replacement of elements was an occurrence every few months, it was reported by C. A. Murray and N. S. Banta of Pure Oil's Nederland, Texas, refinery staff.

William A. Boles of The Lunkenheimer Company, reported at length on various types of valves and the numerous trims best suited for different services; the advantages of the three main designs of valve and the type of service for each design is best. *What not to do as* well as *what to do* to obtain the best results and avoid needless troubles were outlined in considerable detail, the report amounting to a working manual for refinery people on the handling, servicing, and choosing of valves to get the best returns. * * *

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REFINING AND PETROCHEMICAL PERSONALS

G. R. Bryant

▸ Jefferson Chemical Company, Inc., has a new president—**George R. Bryant,** until recently vice president of The Texas Company. The new chief executive stepped into his role February 1. He succeeds **P. M. Dinkins,** who will continue to serve Jefferson Chemical in a consulting capacity. Jefferson Chemical is jointly owned by The Texas Company and American Cyanamid Company.

▸ **Fred L. Hartley** is new vice president in charge of research and process for Union Oil Company. With the company for 16 years, his promotion came at the retirement of **Claude E. Swift,** who held the vice presidency.

▸ Petroleum Chemicals, Inc., a new petrochemical firm owned half by Cities Service Company and Continental Oil Company, has announced new officers and directors. **W. Alton Jones** of Cities Service is chairman of the board and **L. F. McCollum** is president. **A. P. Frame,** who won recognition as chief engineer for building Cities Service's wartime refinery at Lake Charles, Louisiana, is a new vice president. **Harold B. Osborn,** Continental, protegee of the late Walter Miller, is another new vice president. **B. R. Johnston** of Cities Service is secretary and treasurer; **Keith Blinn,** Continental, and **C. B. Wedum,** are new assistant secretaries. Directors, in addition to Jones, McCollum, Frame and Osborn, are **E. F. Battson, Charles A. Perlitz, Jr., L. C. Peters** and **Dr. John E. Kircher,** all of Continental; and **B. S. Watson, G. L. Mateer, H. L. O'Brien** and **W. H. Price,** all of Cities Service. **F. M. (Jerry) Simpson** is vice president and general manager of the company.

▸ **Dr. Louis C. Gibbons,** one of the nation's top authorities on aviation fuels, has been appointed supervisor of the chemistry section of Ohio Oil Company's new Research Laboratory in Littleton, Colorado. Dr. Gibbons, who studied at Ohio University and Ohio State, was associate chief of Fuels and Combustion Research division for the National Advisory Committee for Aeronautics before he joined Ohio.

▸ **Joseph M. Wilson** and **George W. Foster** have been named to positions of greater responsibility with Shell Oil Company's Wilmington-Dominguez Refineries. Wilson, with more than 26 years with Shell, is assistant superintendent. He replaces **G. A. Lorenz,** who now is superintendent of Shell's Montreal refinery in Canada. Foster succeeds **A. D. Northcutt,** who transferred to Shell's refinery at Anacortes, Washington, as personnel and industrial relations manager.

▸ **Frank R. Grant** has joined George Armistead and Company and will become assistant to **Fred P. Lobban** in Athens, Greece, where the company is acting as technical consultant to the Greek government in connection with oil refinery construction. Grant was with Cooperative Farm Chemicals, Inc., immediately before becoming connected with George Armistead. He is a graduate of the University of Illinois, has worked for Lion Oil Company, Consumers Cooperative Association, and spent two terms in Washington with Petroleum Administration for War and Petroleum Administration for Defense.

▸ New personnel assistant manager of Shell Oil Company's Wilmington refinery is **Walter D. Close,** who until recently was supervisor of industral relations for Shell in San Francisco.

William I. Burt

▸ **William I. Burt,** vice president of manufacturing for B. F. Goodrich Chemical Company, has been named president of Goodrich-Gulf Chemicals, Inc., owned half each by Goodrich and Gulf Oil Corporation. Burt succeeds **William S. Richardson,** president of the B. F. Goodrich Company. He was educated at Ohio State University, and in 1952 was president of the American Institute of Chemical Engineers.

▸ Refinery Engineering Company has announced the appointment of **Donald F. Ferguson** as process engineer. Ferguson joined the Process Department of TRECO on October 4. Before joining the organization, Ferguson served as design and process project engineer in the process department of Eastern States Petroleum Company, Houston, Texas. He holds a BS degree in chemistry and chemical engineering from the University of Houston.

M. F. Wirges

▸ **M. F. Wirges** has moved up from chief process engineer to assistant to the manager of Cities Service Oil Company's Natural Gasoline-Chemical division. An able writer (see *The Petroleum Engineer,* December 1953) and outstanding in local chapter of the American Institute of Chemical Engineers. Wirges joined Cities Service in 1946. **Bob L. Galloway** moved up to superintendent of the division's statistical and projects development department. New assistant to the division superintendent of sales is **George C. Vaughan** and advanced to senior process engineer is **Brenton O. Buck. Edgar C. Carlson** is new superintendent of operations at the company's Ambrose gasoline plant near Blackwell, Oklahoma; He succeeds **Guy W. Duren, Jr.,** who is new gasoline plant superintendent at West Seminole, Texas. New post of gas engineer and tester will be filled by **W. C. Giles** at Odessa, Texas.

Dr. Sliepcevich

▸ The University of Oklahoma school of Chemical Engineering has a new chairman. He is **Dr. Cedomir M. Sliepcevich,** a former member of the chemical engineer faculty at The University of Michigan, and consultant to a number of oil and chemical companies. **Dr. R. L. Huntington,** recently appointed a research professor of chemical engineering, has been relieved of administrative duties so that he can devote more time to research. Chemical Engineering's new chairman is a full professor.

▸ **Oscar Larson** has stepped up from assistant general manager to general manager of Tide Water Associated Oil Company's Avon refinery at Associated, California. Larson succeeds **Thomas O. Edwards,** who recently went to the position of manufacturing manager of the company's Western division.

▸ The Southeastern Texas Section of American Chemical Society will be headed by **J. L. Franklin** as chairman and **B. M. Filbert** as treasurer during 1955. Both men are with Humble Oil and Refining Company's Baytown, Texas, refinery. Dr. Franklin is an alumnus of Texas University and MIT; Filbert went to Penn State.

▸ **Dr. I. Bergsteinsson,** who has been a senior research chemist for Union Oil Company for the past decade, has moved over to Brea Chemicals, Inc., one of Union Oil's subsidiaries. In his new connection, Dr. Bergsteinsson, will be senior market research and development engineer.

▸ **S. R. McMurray** has been named manager of the Ponca City refinery of Cities Service Oil Company. **D. R. McConnohie** has been transferred to the company's East Chicago, Indiana, refinery on special assignment, and **C. W. Rohler** has been appointed chief process engineer at Ponca City. McMurray has been on special assignment in the Bartlesville office of Cities Service. He has been with the company since 1924. McConnohie, who joined Cities Service in 1936, has been a member of the general superintendent's staff since 1951. Rohler came with the company in 1949 and has held various duties at the East Chicago refinery.

▸ **Jack R. Bruner,** formerly a chemical engineer with George Armistead and Company, has joined the refining staff of Hancock Oil Company. He is a graduate of the University of Kansas. He will remain in the Long Beach refinery of Hancock Oil Company in a supervisory capacity.

▸ **David Smith,** of Edmonton, Canada, has been elected to the board of directors of Mid-West Refineries, Inc., of Grand Rapids, Michigan. He was formerly associated with Superior Oil Company and is presently engaged in oil production and exploration in Canada.

▸ After 33 years of service with Tide Water Associated Oil Company, **David Rothbard,** supervisor of the control laboratory at Bayonne, New Jersey, has retired. He joined the company as a chemist in 1921 and became supervisor in 1934.

REFINERY PLANTS SCHEDULED FOR COMPLETION

South Dakota Refinery. Great Plains Refinery & Development Company of Rapid City, South Dakota, has contracted Succop Refinery Engineering Company of Los Angeles, California, to design and construct a 3000-bbl refinery which will be South Dakota's first. It will consist of a crude unit, vacuum unit, Succop cracking unit, poly plant, and crude oil and products storage. The cost of the new refinery will be $3,100,000 and completion is scheduled for about the end of this year.

★ ★ ★

Carbide's Ethylene Oxide Plant, Seadrift, Texas. This new plant is already shipping ethylene oxide, polyethylene, and butadiene. The process is the direct oxidation process pioneered by Carbide. Most of the oxide goes into making ethylene glycol (anti-freeze, etc.) the dinitrate for low-freezing dynamite, moistening agent for cellophane, synthetic detergents, acrylonitrile for Dynel fiber, etc. This is the fifth plant built by Carbide to make this oxide. Butadiene goes mostly into synthetic rubber, or when copolymered with styrene, it forms the base for latex paints.

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Brazilian Refinaria Operating. After a cold-oil testing run the 10,000 bbl refinery of Refinaria de Petroleos de Manguinhos, S. A., was dedicated recently as South America's newest plant. All operations are thermal, no catalytic processes being installed. All process operations are coordinated into one combination battery. East Venezuelan crude will be imported to supply the plant. Unit is so designed that naphtha reforming capacity can be added; it also is designed for operations on Arabian crude. All streams flow hot to the next step, without coolers or intermediate storage. The plant is privately owned.

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UK Platformer in Operation. British Petroleum's first platforming unit to be commissioned in the United Kingdom went into operation in February at Kent Oil Refinery on the Isle of Grain. The platformer at the Company's Llandarcy refinery, South Wales, is to be commissioned in April. Platforming units are already in operation at the group's Aden, Lavera (France) and Hamburg refineries, while one is almost complete at Kwinana, Western Australia. Apart from the Aden platformer and the projected unit at Porto Marghera Refinery, each platformer has a capacity of 5000 bbl a day. That at Aden has a 10,000 bbl a day capacity.

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Platformer for Venice Refinery. Another platforming unit is to be added to the sixth such units being built or in operation at refineries operated by The British Petroleum Company group. The seventh platformer is built at Porto Marghera Refinery, Venice, which is jointly owned by British Petroleum and Azienda Generale Italiana Petroli. It will have a capacity of about 1750 bbl.

G. C.-U. G.-E. B. & S.-N. R. Pensacola Plant. Gulf Chemical-United Gas-Electric Bond & Share-National Research partnership has bought 2000 acres near Pensacola, Florida, and has completed the engineering for a plant there to make ammonia, ammonium nitrate, polyvinyl and other plastics, acetylene, nitric acid. Chemical Construction Company has the building contract, site conditioning already underway. New venture is headed by M. A. Abernathy, erstwhile executive vice president of United Gas Co.

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Research Center Expanding. Provision for large-scale experimental units at its Brea, California, research center along with other added facilities will cost Union Oil Company a million dollars. Largest new unit will be of steel, 65-ft high, and have 330,000 sq ft floor space for these large units, pilot plants, and laboratories, and a second steel unit will have 27,000 sq ft of space for operations that can be carried on out-doors with individual control houses for instrument, operators, etc. Two one-story office buildings will be added also.

The original 1951 construction spent $8 million, built 14 major buildings and units. It is expected that the four new buildings will be completed by the fall of 1955.

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Brea Chemicals Expands. Brea Chemicals, subsidiary of Union Oil Company, is building a 210,000-gal ammonium phosphate plant at Fresno, California. It will be an addition to Brea's aqua ammonia distribution terminal at Fresno and will make and distribute a new phosphate fertilizer solution.

★ ★ ★

State Refinery for Greece. A contract for design and construction of a 30,000 bbl refinery has been announced by the Greek government, closed recently with Hydrocarbon GMBH. of Duesseldorf, Germany. George Armistead & Company of Washington, D. C., advisers to the Greek Government and consulting engineers, aided in evaluating bids, and will supervise the construction. Bids were opened last September and since then have been under careful study. No announcement has been made as yet as to the operators of the plant or of its site. It is understood that a number of oil companies marketing in Greece are interested in operating the plant.

Esso to Supply British Power Station With Oil

The British Electricity Authority's new 300,000-kw Marchwood station will be equipped for dual-firing on coal or oil. This is the outcome of an agreement concluded between Esso Petroleum Company, Ltd., and the Electricity Authority for an estimated 350,000 tons of fuel annually. It will be supplied from the Esso Fawley refinery six miles away. Ultimate annual fuel consumption could reach 600,000 tons, which would equal a saving of about 1,000,000 tons of coal, a commodity of which Britain is critically short.

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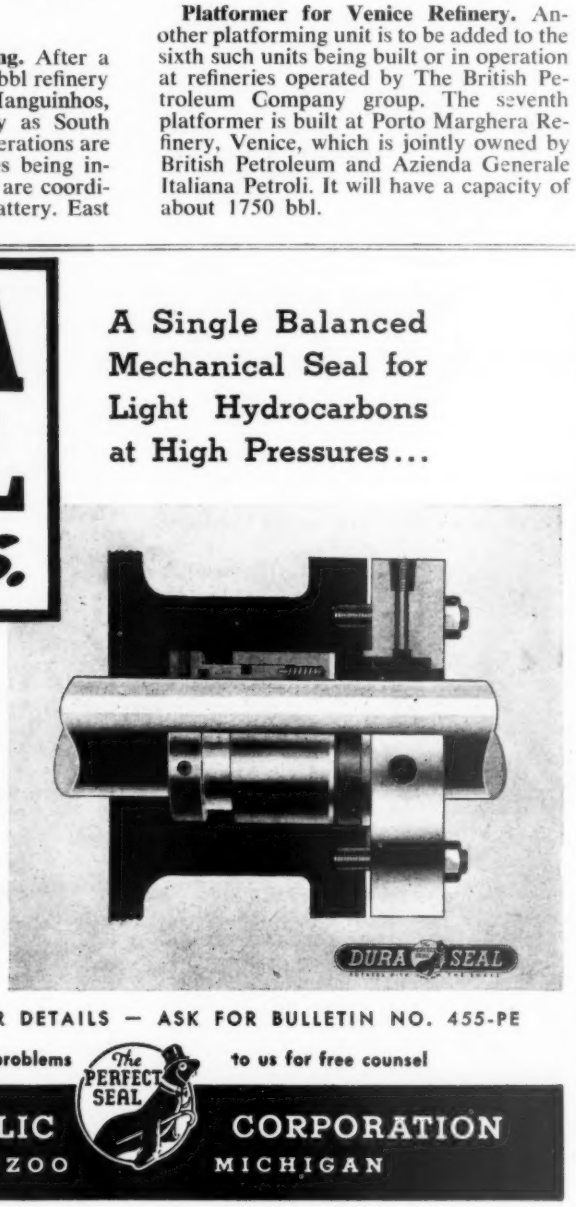

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Defense Pipe Lines: What Next?

The government has reached the crossroads point in the decision-making on several proposed "defense pipe line" projects that would require federal support to move them from the paper stages to operating properties. Chief theme of all the proceedings to date seems to be lack of understanding and coordination, with every conceivable type of interest having a finger in the pie.

Proposals to date by outside planners include the West Coast Pipe Line Company, which wants a military guarantee of 75,000 bbl per day, the operating break-even point on a West Texas-California line, and the American Pipe Line Company, which proposes a 1600-mile Beaumont to New Jersey products carrier, and which is facing competition from the proposed conversion of the "Little Inch" gas line and from barge operators on the Misssissippi and Ohio rivers, not to mention difficulties in getting contracts for supplies of products to carry.

A three-man ODM committee turned "thumbs down" on the West Coast project after hearing the military continue refusal of a guarantee, and noting the possibility that California refining capacity was inadequate to handle the increased supply (without giving up imports.) As for the American proposal, the ODM apparently favors stockpiling pipe at 500 mile intervals along right-of-way it feels the government should purchase in anticipation of possible defense needs for the line. Construction would be undertaken if and when the line were needed. This, apparently, is aimed at striking the "happy medium" between needing and not having—and having and not needing.

Other proposals the ODM 3-man committee is understood to have come up with included: (a) construction of a 50-mile crude line across the Isthmus of Panama; and (b) construction of a crude line from the now famous Elk Hills Naval Reserve in California to the San Diego refinery area. Both might find considerable opposition in Congress. And both seem to be awkward steps for sane people.

★ ★ ★

News Nuggets:

Westcoast Transmission Company, Ltd., will ask the Alberta provincial conservation board to allow it to increase its authorized withdrawals of natural gas from the Peace River area of Alberta, with most of the gas scheduled for export to the northwestern area of the United States. The firm is requesting authority to raise its annual supply from 42 to 56 billion cu ft per year.

The company has also announced preliminary plans for a second gas pipe line from the Peace River area to the United States. The second line, said the firm, would be justified by the reserves in the gas fields as they are determined in the next five years.

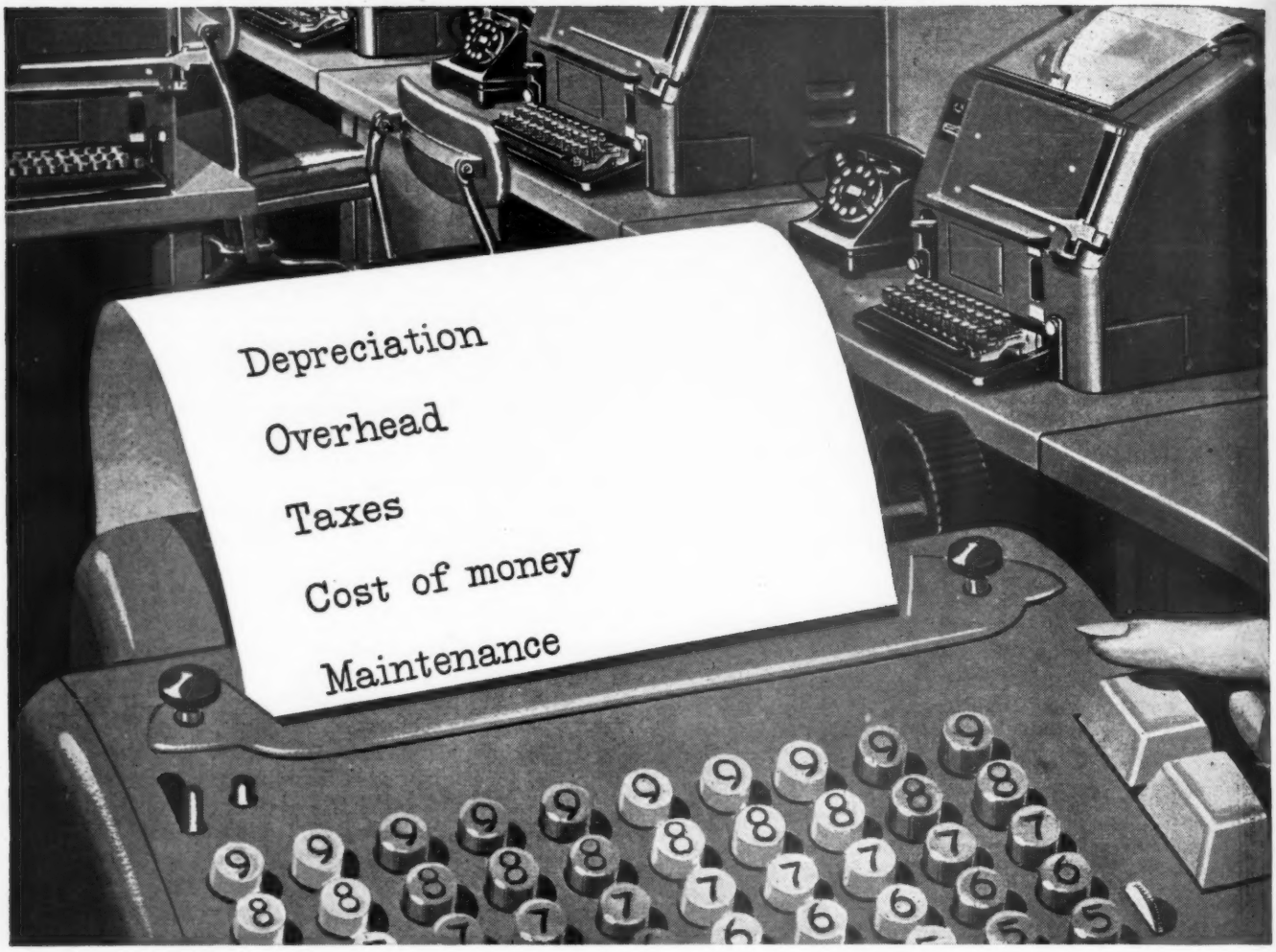
In addition to the Alberta gas, Westcoast will also take some 70 billion cu ft per year from British Columbia gas fields. Coupled with the proposed Alberta increase, the firm would be able to supply some 300,000,000 cu ft daily to the Pacific Northwest Line for markets in the northwestern U.S. and 50,000,000 for British Columbia markets. Westcoast and Pacific Northwest Pipe Line recently signed a contract for delivery of Canadian gas to the new U.S. line.

Natural Gas Pipeline Company of America has been given a March 8 date on its hearing for authority to construct a $28,500,000, 240-mile gas pipe line between Wise County and Amarillo, Texas. Also involved in the hearing will be applications by Mid-Continent Petroleum Corporation, Warren Petroleum Corporation, Oil Drilling, Inc., and a number of individual independent gas producers who would sell gas to the pipe line company.

Cherokee Pipe Line Company has announced plans to construct products terminals at Oklahoma City, Oklahoma; Mount Vernon, Missouri; Wood River, Illinois; and Wichita, Kansas, at a total cost of about $3,000,000. Work is to start immediately and to be completed by late spring. Cherokee has a 570-mile Oklahoma City to Wood River products line and an 83-mile Ponca City to Wichita products line. The company was formed last year by Cities Service Pipe Line Company and Continental Oil Company.

Sioux Oil Company plans to build a 55-mile, 8-in. products line between Newcastle, Wyoming, and Rapid City, South Dakota. The firm recently announced plans to expand the capacity of its two refineries at Newcastle. Both projects are part of a $4,000,000 expansion program for 1955.

"ALL RIGHT, SUPPOSE EVEN IF WE FIND OIL ON THE MOON... THINK OF THE PROBLEMS INVOLVED IN BUILDING A PIPE LINE THRU 250,000 MILES OF OF EMPTY SPACE!"



If you provide your own communications system...

HAVE YOU ADDED UP ALL THESE COSTS?

Owning and operating your communications system can be a costly experience, with many costs frequently overlooked. Depreciation, taxes, overhead, maintenance, loss of interest on capital all contribute to your total communication expense.

Bell System communications are low in cost. You pay only a fixed monthly charge for services and facilities tailored to your exact needs. No more, no less. Your capital is not tied up but left free for income-producing investments in *your* business.

The installation of your communications is just the beginning of the Bell System job. Maintenance, replacement, inventory, storage, extension and rearrangement are all handled rapidly and efficiently—no longer problems for you.

Let us show you how Bell System know-how and experience can be put to work to solve your communications problems. For a complete communications study, made without charge, call your local Bell Telephone representative today.

TELEPHONE

TELETYPEWRITER

MOBILE RADIO

METERING CHANNELS

BELL TELEPHONE SYSTEM

PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Current Planned and Proposed Construction

NAME OF COMPANY	MILES	PIPE SIZE	LOCATION
CRUDE LINES			
Ar-Mex Pipeline Co.	790	12-14	Guernsey, Wyoming to Coolidge, Arizona
Kaybee Pipe Line Company	46	10	Griffith, Indiana, to New Buffalo, Michigan
Michi, Inc.	222	10	Highland, Indiana, to Elsie and Alma, Michigan
NNCW Pipe Line Co.	127	8-10	Weston County to Casper, Wyoming
Orchard Pipe Line	45	8	Orchard to Merino, Colorado
Peace River Oil Pipe Line Co., Ltd.	200	12-16	Peace River area to Edson station on TransMountain near Edmonton, Alta
Powder River Pipe Line Company	436	10-16	Williston Basin to Laurel and Billings, Montana
Proven Oil & Refining Company	32	8	Connection with West Coast Pipe Line to Florence, Ariz.
Roosevelt Oil & Refining Corp.	22	4.6	St. Helen to Norwick, Michigan
Standard Pipe Line Co.	350	16	Glendive, Montana, to Guernsey, Wyoming
Standard Pipe Line Co.	350	16	Wink, Texas, to Albuquerque, New Mexico
Sinclair Pipe Line Company	31	12-16	Monee to Lemont, Illinois
Trans Mountain Oil Pipe Line Corp.	27	20	Laurel Junction to Mt. Vernon, Washington
West Coast Pipe Line Company	960	20-22	Wink, Texas, to Norwalk, California
PRODUCTS LINES			
American Pipe Line Company	1910	8 to 26	Beaumont, Texas, to Newark, New Jersey, with laterals
California-Oregon Pipe Line System	103	6	Crescent City, California, to Medford, Oregon
H. W. Bass & Sons, Incorporated	152	4-6	Duval and Live Oak Counties, Texas, to Corpus Christi, Texas
Bell Oil and Gas Company	140	6-8	Ardmore to Cushing, Oklahoma
El Paso Natural Gas Co. (LPG Line)	119	3-6	Bloomington to Gallup, New Mexico
Great Lakes Pipe Line Co.	162	10	Eldorado, Kansas, to Kansas City, Missouri
Goliad Corporation (LPG Line)	117	4-6	Kittie Plant to Corpus Christi, Texas
Inland Corporation	22	6	Springfield to Dayton, Ohio
Inland Corporation	37.5	10	Toledo to Fostoria, Ohio
International Pipe Line Inc.	132	8	Wrenshall to Minneapolis, Minnesota
Keystone Pipe Line Company	48	8	Boot Station to Fullerton, Pennsylvania
Malco Pipeline, Inc.	91	6	Prewitt to Albuquerque, New Mexico
Mayflower Pipe Line Company	—	—	New Jersey refineries to New England points
Moore-Stoner Company	200	6	Glendive, Montana, to Minot, North Dakota
Phillips Petroleum Company	52	10	Shell's Brookshire system to Sweeny, Texas
Products Pipe Line Co.	90	5½	Lavaca County to Texas City, Texas (LPG Line)
Shamrock Oil & Gas Corporation	55	6	McKee to Amarillo, Texas
Sioux Oil Company	50	6	Newcastle, Wyoming, to Rapid City, South Dakota
Sunflower Pipe Line Company	265	3-6	Kearny, Grant and Haskell counties to Wichita, Kansas
Texaco-Cities Service Pipe Line Company	45	8	West Tulsa to Cushing, Oklahoma
Winnipeg & Central Gas Co. (LPG Line)	450	4 or 6	Tioga, N. D., to Winnipeg
GAS LINES			
Alberta Gas Trunkline	315	18-36	Gas Gathering System in Alberta fields
American-Louisiana Pipe Line Company	1120	22 & 30	Lowry, Louisiana, to Detroit, Michigan
Anadarko Basin Pipeline Co.	525	24	Wise County, Texas, to Memphis, Tennessee
Arkansas-Louisiana Gas Company	136	8 to 24	Loops on System
Central Hudson Gas and Electric Co.	48	12	TGT line to Kingston, N. Y.
City of Fayette, Alabama	20	5	Fayette, Alabama, to Southern Natural's system
Coast Counties Gas Electric Company	40	3-4-8	Coast and Valley Region, California
Coastal Transmission Corporation (c/o Delhi Oil, Dallas)	400	30	McAllen to Beaumont, Texas
Colorado Interstate Gas Company	365	22	Green River, Wyoming to Denver, Colorado
Colorado Interstate Gas Company	110	6-8	Julesburg area to Denver, Colorado
Colorado-Western Pipe Line Co.	328	16-18	Ignacio field to Pueblo and Denver
Colorado-Western Pipe Line Co.	454	—	Cortez to Denver System
Colorado-Western Pipe Line Co.	250	—	Lateral lines
Cumberland and Allegheny Gas Co.	31	12	Garrett County, Maryland, to Keyser, West Virginia
El Paso Natural Gas Co.	370	—	Mountain Home, Idaho, to Reno, Nevada
El Paso Natural Gas Co.	74	—	Additions to Permain Basin-San Juan Basin system
Fort Worth Basin Gas Company	—	—	Brown and Comanche counties, Texas
Kansas Pipe Line Company	125	16-20	Barber County fields to Wichita, Kansas
Kansas-Nebraska Natural Gas Company	206	6-12	Additions to Nebraska system
Manufacturers Gas, Light & Heat	40	—	Allegheny, Washington, and Beaver counties, Pa.
Manufacturers Gas, Light & Heat	213	3 to 26	Various points on system in Pa., W. Va., and Ohio
Manufacturers Gas, Light & Heat	72	16-20	Doddridge, Wetzel and Marshall Counties, West Va.
Michigan Consolidated Gas Company	25		Sparta to Muskegon, Michigan
Michigan-Wisconsin Pipe Line Company	252	4-24	Loops and stations in Illinois
Mississippi River Fuel Corporation	190	10-18	Laterals in Woodlawn and Waskom gas fields, Texas
Morganfield Natural Gas	31	4-6	Through Sturgis, Providence, Clay, Diamond, Wheatcroft and Sullivan, Kentucky
Natural Gas Pipe Line Co. of America	280	24	Amarillo to Wise County, Texas
Natural Gas Producer, Inc.	100	12	Yenter pool to Denver, Colorado
Natural Gas Producer, Inc.	61	4-10	Northeast Colorado lines
Natural Gas Storage Company	35	36	Storage field areas near Chicago to main lines
New River Gas	50	—	Sumners to Monroe counties, West Virginia
North Dakota Natural Gas Company	475	6-12	Statewide system in North Dakota
Northern Indiana Fuel & Light	35	8	Edgerton to Alburn, Indiana
Northern Natural Gas Company	330	2-12	System in South Dakota
Northern Natural Gas Company	310	24	Lines in North Dakota
Northern Natural Gas Co.	403	24-30	Canadian border to Minneapolis-St. Paul
Northwest Utilities Ltd.	42	—	Bonnie Glen to Edmonton, Alberta, Canada
Pacific Northwest Pipeline Corp.	1486		Ignacio, Colorado to Bellingham, Washington
Pacific Northwest Pipeline Corp.	380		Laterals and spurs off main line to Pocatello, Idaho, to Yakima, Washington
Pine Tree Natural Gas Co.	204	—	Boston to Bangor, Maine
Rockland Light & Power Company	22	8	Orangetown to Tompkins Cover, New York
Shenandoah Gas Company	39	3-4-8	Middleton, Virginia, to Martinsburg, West Va.
South Georgia Natural Gas Company	368	2-12	Phoenix, Alabama, to Tallahassee, Florida
Tennessee Gas Transmission	243	24	Hebron, Pennsylvania to Greenwich, Connecticut
Tennessee Gas Transmission	370	30	Agua Dulce, Texas, to Kinder, Louisiana
Texas Eastern Transmission Corp.	328	24	Beaumont to Kosciusko, Mississippi
Texas Gas Transmission Co.	90	20-26	Loops on main line
Texas Gas Transmission Co.	100	10-20	Loops on southern Indiana system
Transcontinental Gas Pipe Line Corporation	125	—	Ulster County, New York (Pheoncia) to New York City
Transcontinental Gas Pipe Line Corporation	173	30-36	Loops on main system
Transcontinental Gas Pipe Line Corporation	58	12-16	Other new lines
Trans-Canada Pipe Lines, Ltd.	2247	14-36	Alberta area to Toronto, Montreal
Union Gas Company of Canada	180	—	Dawn Storage field to Hamilton
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania
Utah Natural Gas Company	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Va.
Warren Petroleum	54	4-30	Lea County, New Mexico
Westcoast Transmission Co., Ltd.	650	24	Peace River area, Alberta, to U. S.-Canadian border
Wyoming Gas Products Corp.	—	—	Gas gathering system in Weston County, Wyoming

Oil & Gas Journal

New Pipe-Laying Record

IF you want to lay a pipeline faster, take advantage of the human competitive element.

That's what Service Pipe Line Co. did in building its 625-mile crude-oil line from Fort Laramie, Wyo., to Freeman, Mo., a... themselves.

Two contra... completed we... ...ch cruc...

was done without any special organization within Service Pipe Line.

There was a normal incentive to hurry for both Service and its contractors, O. R. Burden Construction Corp., Tulsa, and H. B. Zachry Co., San Antonio. For Service there was the ... economy of opera...

Wall Street Journal

Pipeline 625 Miles Long Completed in Just 61 Days

Special to THE WALL STREET JOURNAL

TULSA Welding of the final link in a 625-mile Wyoming-Missouri crude oil pipe line was completed by Service Pipe Line Co. just 61 days after the job was started.

Completion of the line, which will broaden crude transpor'ation facilities out of the Rocky... oil fields, was be... fastest pipe-laying ... to the company. 10 miles a day of ...ameter line was ...with better than ... machines used.

Fort Laramie, ... Freeman, Mo., ...

Pipe Line Industry

WHAT'S HAPPENING

IN PIPE LINE CONSTRUCTION

Service Line Completed in Record Time

Service Pipe Line Company, a transporter of crude oil, set a world's record for laying large-diameter pipe when the final weld on its 625-mile Wyoming-Missouri line was completed at noon, November 15. The ... coating, only 1600 feet behind, was ...

of-way option was taken on August 18 and the first pipe shipped from the mill August 20. The first survey crew was in the field August 24, and contracts for construction were awarded August 25.

Servi... ...d the project into ...

Allis-Chalmers Tractors help Zachry Rush Work on Record-Setting 10-mile-a-day pipe-laying job

On one of the most publicized pipe-line operations of 1954, men and machines pushed through Service Pipe Line Company's 625-mile, 20-24-inch pipeline job from Ft. Laramie, Wyoming, to Freeman, Missouri, at the amazing rate of 10 miles per day. Leading industry publications acclaim the operation as a world's speed record for setting large-diameter pipe — faster than the Big Inch lines of World War II or any postwar pipe-line undertaking.

XUM

Speed for Welders

There's big work capacity in the 10-ton, 84-belt-hp HD-9. Highly maneuverable, it helped fast-moving welding crews roll along. Side boom operates through front power take-off, independent of master clutch, leaving rear of tractor free for winch. With dual clutch side boom control — one for raise, the other for lower — the operator merely pulls one lever to switch from *raise* through *neutral* to *power down* — no gear shifting necessary. According to Zachry personnel, the combination of the HD-9's speed and the smooth, fast-working side boom was a very important factor in the success of the operation.

Speed on Dozing

This rugged 15-ton 124-belt-hp HD-15 Tractor speeded operation on both right-of-way clearing and cleanup. With the Allis-Chalmers simplified shift pattern, it takes just half the time and effort to change from low forward to fast reverse on the HD-15 — you shift one lever instead of two. On short-run dozing jobs where frequent shifts are required, the HD-15 can make five passes in the time usually required to make four — actually increasing production up to 25 percent.

Speed on Cradling and Lower-In

Twenty-ton powerhouse provides the big lift. Pictured is the 175-net-engine-hp HD-20 Torque Converter Tractor cradling 20-inch pipe for dope-wrap machines. With torque converter drive — an Allis-Chalmers first in crawler tractors — it's easy for operator to match speed to clean-prime or dope-wrap machines with unequalled smoothness. Operator regulates speeds through throttle control. Walter Bauerschlag, Colorado section spread foreman, said the extra lifting capacity of the HD-20 Tractors enabled them to stay well away from the ditches and avoid cave-ins due to sandy soil conditions. The 20's ability to stay clear kept lowering-in operations moving at a fast, steady pace.

Allis-Chalmers Tractors Help Maintain "Race Horse" Pace

H. B. Zachry, San Antonio, Texas, operated four spreads with Allis-Chalmers tractors to handle the western half of the job. Two spreads were 100 percent Allis-Chalmers equipped. Tractors were delivered new by the dealer. These consisted of:

- *4 HD-20 Torque Converter Tractors with side booms*
- *6 HD-15 Torque Converter Tractors with side booms*
- *8 HD-15 Tractors with angle dozers*
- *5 HD-9 Side Boom Tractors with unique front control clutches*
- *2 HD-9 Tractors with backfillers*

According to Mr. A. "Pup" Vaughn, General Superintendent, even at this top-speed pace, no operating time was lost because of equipment downtime on either of these two all-Allis-Chalmers spreads.

Dealer Service Excellent

The Zachry personnel was highly complimentary of Allis-Chalmers dealer service. Delivery of equipment was fast and complete. The machines arrived on schedule in top shape, ready to go to work. On-the-job dealer cooperation was excellent.

Zachry Rates Allis-Chalmers Best

Based on performance, both Mr. Zachry and Mr. Vaughn were outspoken in their praise of Allis-Chalmers pipe-line equipment. They regard it as the finest available today.

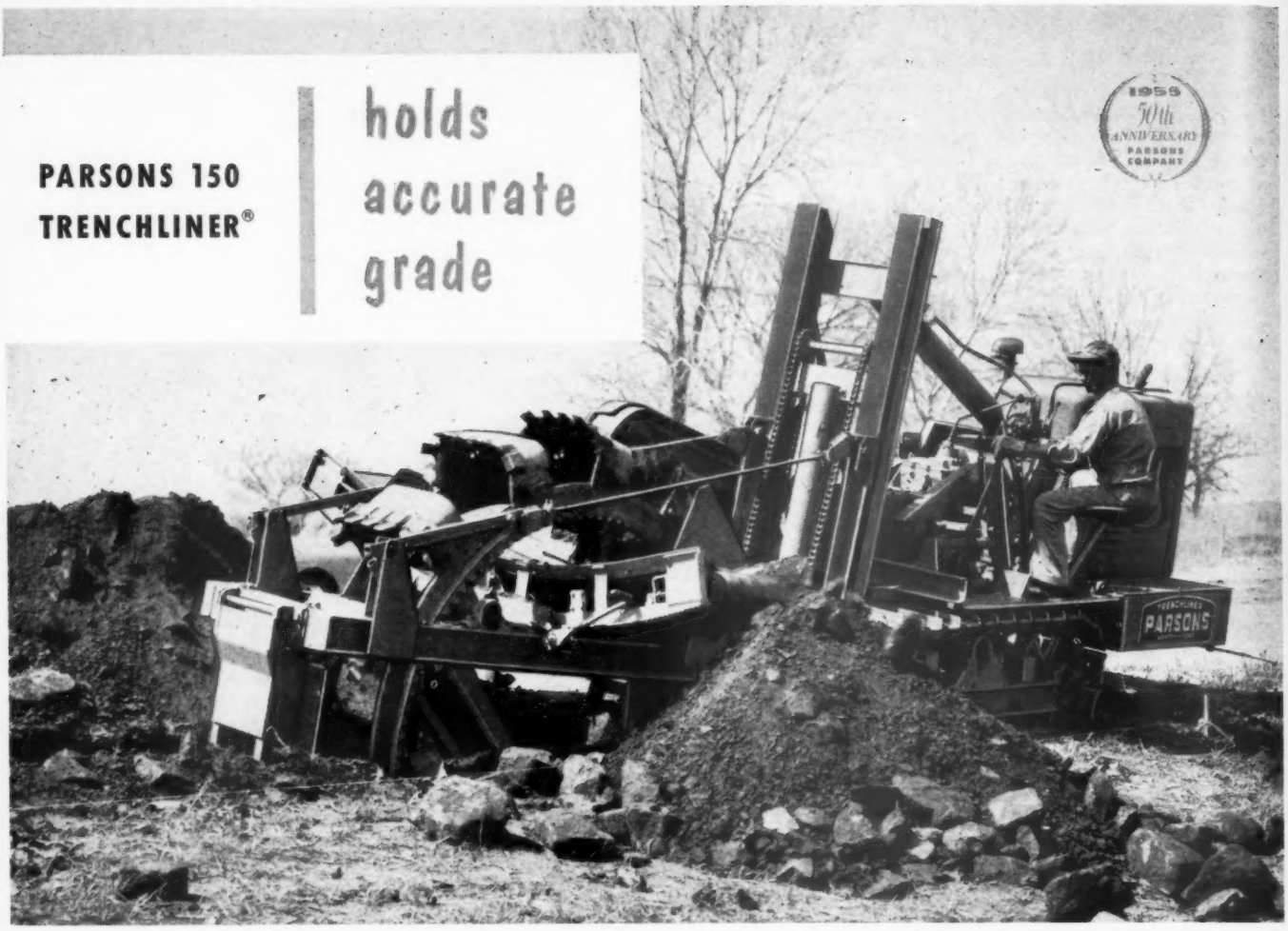
Convince Yourself With a Demonstration

Find out as others have, how this equipment can speed your jobs. Your Allis-Chalmers dealer will be happy to demonstrate.

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

PARSONS 150 TRENCHLINER®

holds accurate grade



Hydraulic power raises, lowers, tilts the digging wheel

Hydraulic wheel-hoist control on Parsons 150 heavy-duty Trenchliner maintains close grade tolerance in toughest digging — an important advantage on cross-country transmission lines, feeder and gathering lines. Hydraulic ram on vertical mast raises and lowers the digging wheel with fractional-inch accuracy. A separate hydraulic ram tilts the mast — balances weight of wheel forward for traveling or trailer-loading.

Heavy-duty digging wheel takes either square or round-bottom, cast-steel buckets, with solid or tine backs. For digging dry or wet materials, the quick-change buckets have gumbo lips, or self-sharpening, reversible "Tap-In" teeth. Belt conveyor, 24 inches wide, is shiftable, reversible, discharges spoil to either side.

Standard tractor crawlers on this Parsons 150 Trenchliner have 16-inch treads, grouser-type shoes — provide plenty of sure-footed traction for cross-country work. Yet, ground-bearing pressure is low, only 6.3 pounds PSI. For power, you have a choice of standard-make gas or diesel engine. Find out how this heavy-duty 150 Trenchliner fits into your pipeline spread, for main-line trenching — or as an auxiliary unit for digging laterals and gathering lines. Get in touch with your Parsons distributor or write us for bulletin.

Digs up to 25 ft. per minute—16 to 26 in. wide—5¾ ft. deep.

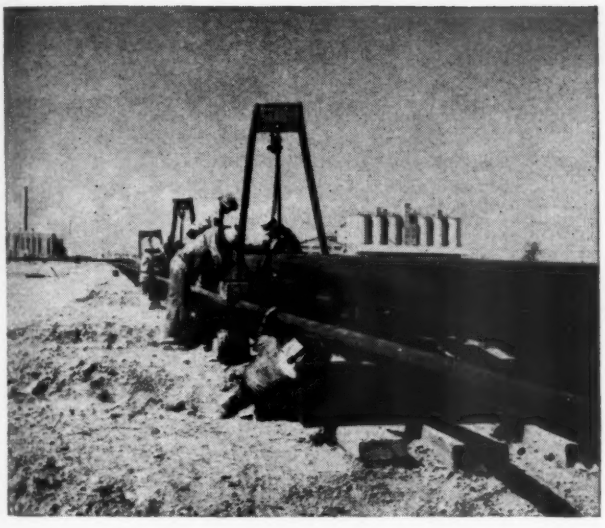
Send to: **PARSONS COMPANY, Newton, Iowa**
(Koehring Subsidiary)
for bulletin on 150 wheel-type Trenchliner

NAME_____
TITLE_____
COMPANY_____
DIVISION_____
STREET_____
CITY, STATE_____ P559 PE

5 other sizes of Parsons Trenchliners include wheel and ladder-types, full crawler mounted . . . and a rubber-tired Trenchmobile.®

Here's how they KO'd SULPHUR, CHEMICALS, SALT AIR and HEAT on this Refinery Pipe line!

1. It takes no special equipment to apply Pitt Chem. Here, applicators brush on 101 about 12 mils thick.



2. Pitt Chem applies easily, even on awkward underside. Crew learned to apply it in a few minutes.

3. Pitt Chem 101 was economical to purchase and apply. It will protect this line against corrosion for years.

MAINTENANCE engineers at this Southwestern refinery realized that no ordinary coatings could protect these pipelines from the metal-eating conditions they faced. Today, the lines are safely protected with an impervious film of *Pitt Chem*® Tar Base Coating, the material that *naturally* resists practically all major types of industrial corrosion.

Pitt Chem Tar Base Coatings are tailor-made for protecting oil producing and refining equipment against corrosion. They are highly resistant to petroleum products as well as mineral acids, alkalis and moisture. They are economical to buy and easy to apply.

No other material does such a complete job of protection at so little cost. That's a big statement, but our corrosion engineers have the facts to prove it.

If you have a corrosion problem—and never mind how tough it seems—contact us today. You may be surprised how quickly and economically it can be solved.

W&D 5485

COAL CHEMICALS • AGRICULTURAL CHEMICALS • FINE CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON

Sections of this recently completed 462-mile products line of the Oklahoma-Mississippi Products Line, Inc., running through Arkansas from Duncan, Okla., are corrosion-protected by Transhield.

Johns-Manville TRANSHIELD® ASBESTOS PIPE LINE FELT

goes on fast, restricts soil stress, cuts maintenance

Transhield Asbestos Pipe Line Felt meets the need for a felt that is economical yet effective in all ordinary soil conditions.

Designed for easy, high-speed application by modern machine methods, Transhield is strong, light in weight, and highly tear-resistant. Longer length rolls increase application speeds since fewer stops to replace rolls are required. Transhield's highly desirable characteristics are attained through an innovation in felt construction. It consists of a lightweight coal-tar saturated asbestos felt, reinforced with continuous glass yarns parallel-spaced on ¼" centers.

Because Transhield is a continuous membrane between the pipe line enamel and the soil, it works effectively toward preserving a continuous protective film of enamel on the pipe. It guards the enamel during construction and, after installation, it reduces the cold flow of the enamel, acting as a surface barrier to restrict soil stress.

• • •

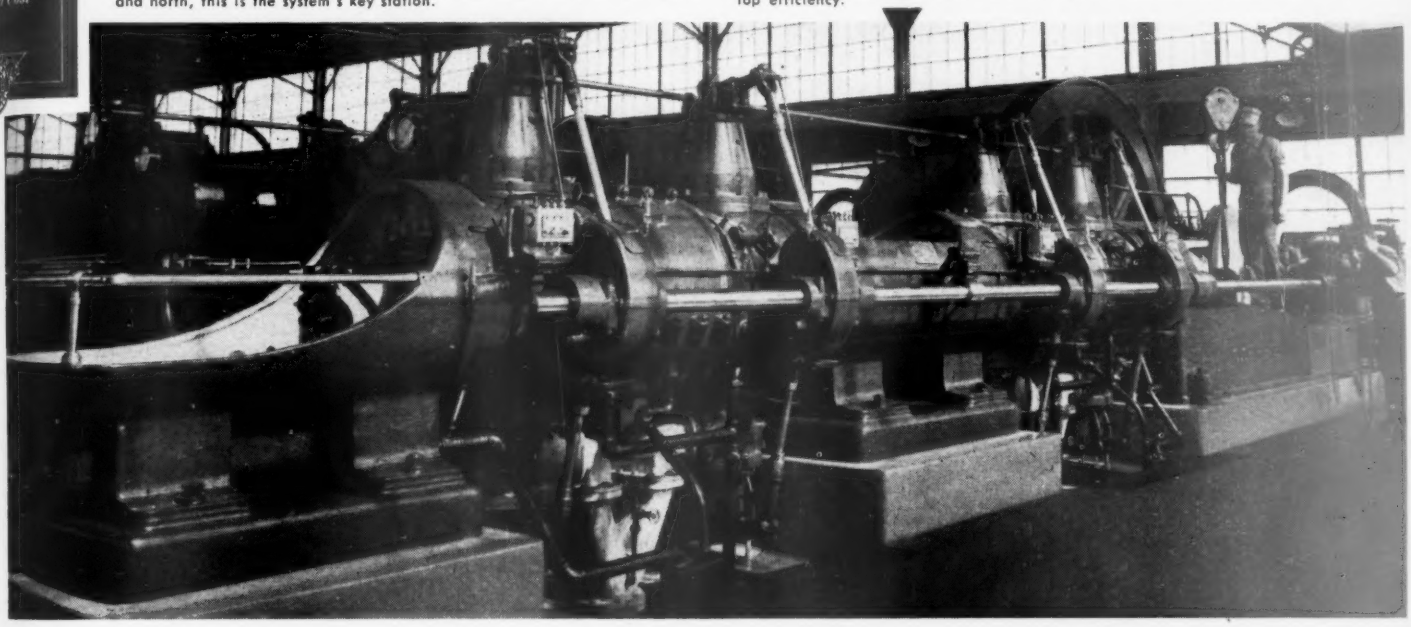
For further information about Transhield, write to Johns-Manville, Box 60, New York 16, New York; in Canada, 565 Lakeshore Road East, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** PRODUCTS FOR PIPE LINE PROTECTION

XUM

Line-up of modern 10-cylinder GMV's in the Gwinville, Mississippi, station of the Southern Natural Gas Company. GMV-powered and strategically located at the junction of the main supply line to the east and north, this is the system's key station.

This horizontal Type-22 Cooper-Bessemer twin-tandem unit in the Tarrant, Alabama, compressor station dates back to 1937 when this, then modern, unit was first installed. Today, after 17 years, it continues to operate at top efficiency.



Cooper-Bessemers total 700 years of service FOR SOUTHERN NATURAL GAS

NINETY Cooper-Bessemer units — modern GMV's, and still newer GMVA's (providing still lower fuel consumption and decreased water requirements) and older style horizontals — have totaled more than 700 years of reliable compressor service for Southern Natural Gas Company.

The first of these units dates way back to 1930 — 24 years ago! And with each expansion more and more Cooper-Bessemers were added to Southern's system — proof of lasting satisfaction — evidence that you, too, can count on modern Cooper-Bessemers for year in, year out compressor service at the lowest operating costs known today.

Whatever your compressor requirements, make sure you find out about the latest advancements being offered by one of the nation's oldest compressor builders — Cooper-Bessemer.

MOUNT VERNON, OHIO

COOPER-BESSEMER

GROVE CITY, PENNA.

New York City • Seattle, Wash. • Bradford, Pa. • Chicago, Ill. Houston, Dallas, Greggton, Pampa and Odessa, Texas Washington, D. C. • Shreveport, La. • San Francisco, Los Angeles, Calif. • St. Louis, Mo. • Gloucester, Mass. • New Orleans, La. • Tulsa, Okla. • Cooper-Bessemer of Canada Ltd., Edmonton, Alberta—Halifax, Nova Scotia.

DIESELS • GAS ENGINES • GAS-DIESELS • ENGINE-DRIVEN AND MOTOR-DRIVEN COMPRESSORS

Pritchard-built dehydration plant of the Southern Natural Gas Company in Gwinnville, Miss. Note two Pritchard Fin Coolers® just left of ce

DRY *means* **DRY** especially when you're talking about treating natural gas. There can be no if's, and's or but's.

That's why the gas industry has grown to respect and specify Pritchard for the engineering and construction of dehydration plants. When Pritchard designers say dry, they *mean* dry. Yes, Pritchard has proved its exceptional ability to design and engineer such facilities. And, then, follow up with construction that is directly translated into greater production and profit for you.

Let Pritchard solve your gas treating problems. Specify Pritchard on your next dehydration plant.

INDUSTRY'S PARTNER FOR PROGRESS

SERVING THE GAS, POWER, PETROLEUM AND CHEMICAL INDUSTRIES

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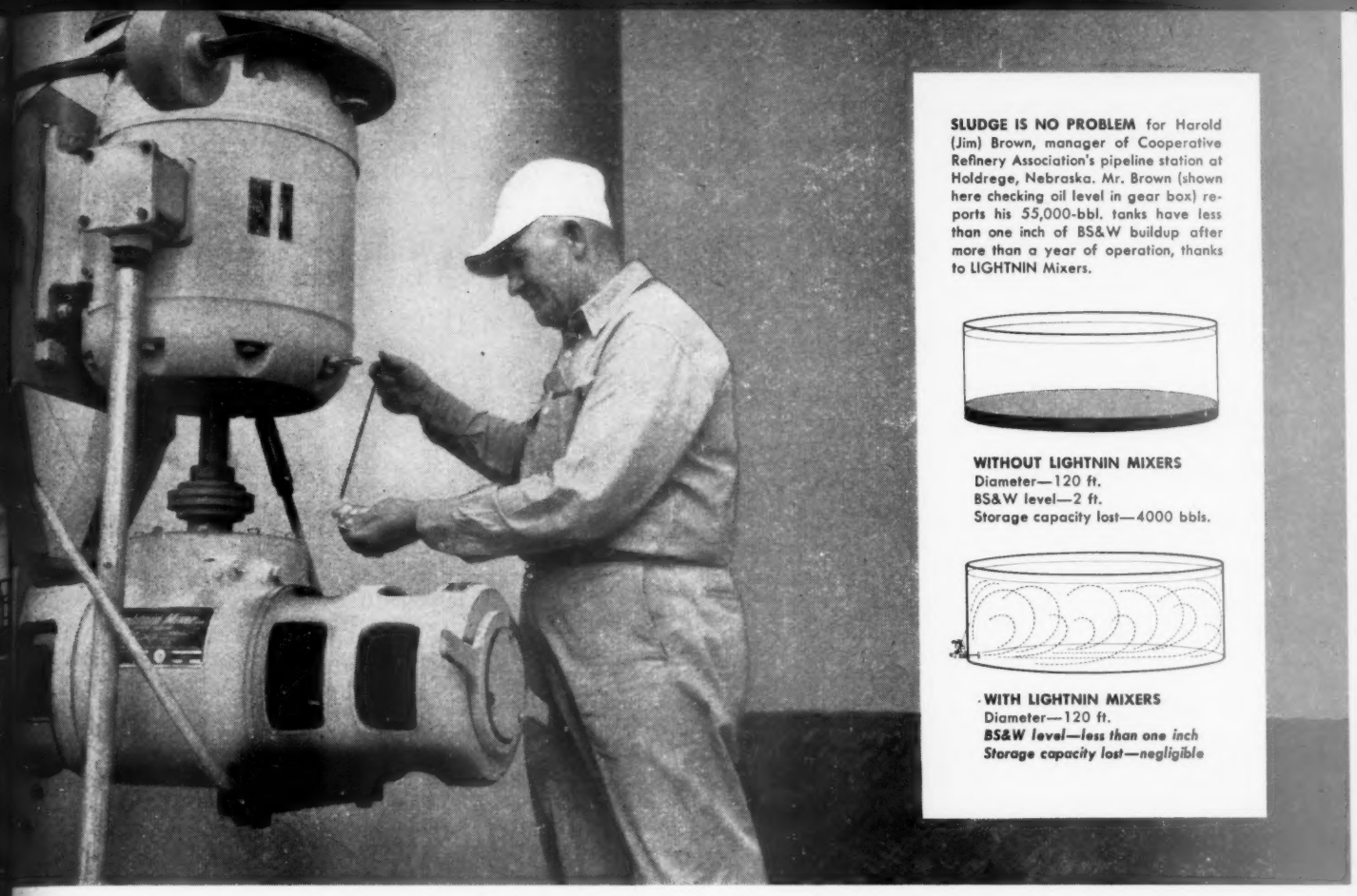
ENGINEERS • CONSTRUCTORS

Dept. 437, 4625 Roanoke Parkway, Kansas City 12, Mo.



SLUDGE IS NO PROBLEM for Harold (Jim) Brown, manager of Cooperative Refinery Association's pipeline station at Holdrege, Nebraska. Mr. Brown (shown here checking oil level in gear box) reports his 55,000-bbl. tanks have less than one inch of BS&W buildup after more than a year of operation, thanks to LIGHTNIN Mixers.

WITHOUT LIGHTNIN MIXERS
Diameter—120 ft.
BS&W level—2 ft.
Storage capacity lost—4000 bbls.

WITH LIGHTNIN MIXERS
Diameter—120 ft.
BS&W level—less than one inch
Storage capacity lost—negligible

Is sludge hogging your tank capacity?

Cooperative Refinery Association cleans tanks by flipping a switch. So can you.

Sludge is a tank hog. It eats up valuable tank capacity you badly need for crude. It's a messy tenant, too, and cleaning up after it is a costly, dirty job.

Rid your tanks of sludge, and you add as much as 12% more capacity to your pipeline stations.

Cooperative Refinery Association brings crude oil from Wyoming to its pipeline station at Holdrege, Nebraska, stores it in two 55,000-bbl. tanks. When the crude moves on to the refinery at Phillipsburg, it leaves a minimum of BS&W in the tanks. In more than a year of operation, scarcely an inch of sludge has accumulated in either tank.

Simple method pays off

Secret? Cooperative Refinery Association equipped each tank with a LIGHTNIN Side Entering Mixer. When temperature falls below 70°, these mixers go to work for about four hours a day. They keep bottoms stirred, prevent oil from congealing. When the oil moves on, each tank is ready to take on a new supply—without cleaning—and at full capacity.

LIGHTNIN Mixers are keeping storage tanks free of sludge at many pipeline stations, increasing storage capacity, eliminating downtime for cleaning, making every barrel in every tank merchantable crude oil.

Here's why you can't lose

You take no risk when you order a LIGHTNIN. Every one is unconditionally guaranteed to perform its job—or your money back.

Learn how LIGHTNINs can solve your sludge problems, make your tanks work harder, cut your costs. Call in your LIGHTNIN representative, or write us today.

Lightnin® Mixers

XCO fluid mixing specialists

Get these helpful facts on BS&W control and LIGHTNIN Mixers. Check, tear out and mail to us today with name and company address. Free—no obligation.

- ☐ B-503 Illustrated bulletin on BS&W control
- ☐ B-104 20-page catalog fully describing LIGHTNIN Side Entering Mixers
- ☐ B-107 Mixing Data Sheet
- ☐ B-110 Condensed Catalog describing LIGHTNIN Mixers of all types
- ☐ B-111 Bulletin describing LIGHTNIN rotary mechanical seals for extra-low-cost mixing

MIXING EQUIPMENT Co., Inc., 127-c Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 10, Ont.

XUM

New Technique For Gas Dispatching

L. B. Lumpkin*

Described here briefly is a system of telemetering recently installed by the Mississippi Valley Gas Company. The system involves a unique combination of selective calling communication facilities, time-impulse telemetering, and time-multiplexing.

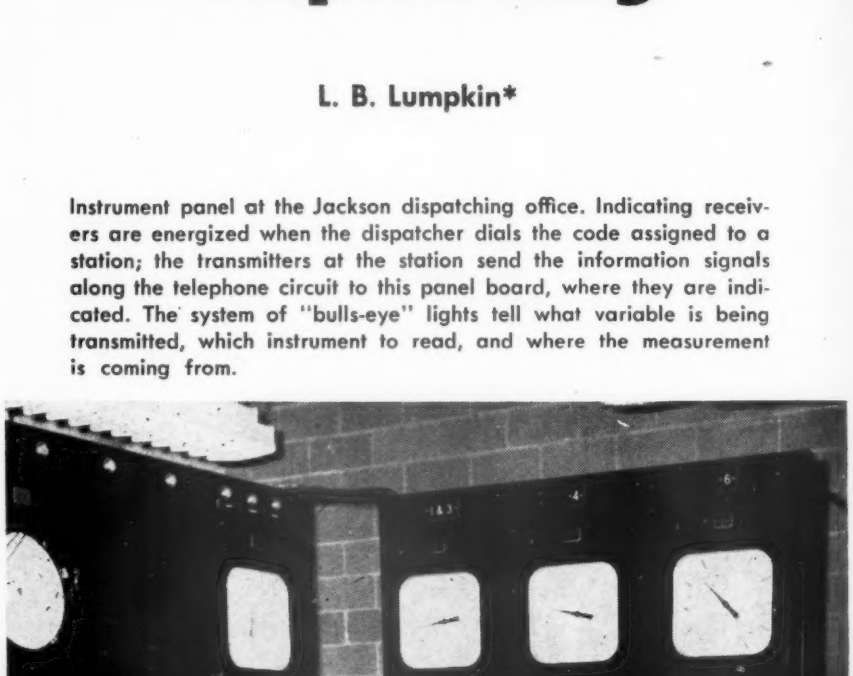
Representing a significant step forward in the techniques of effectively utilizing the flexibility of measuring instruments, telemetering equipment and specially designed communication facilities, Mississippi Valley's solution should be of interest to pipe line engineering and operating people interested in modern instrumentation practices.

The problems of gas distribution, gas transmission and oil pipe line companies are similar; they differ only in degree or detail, and many will yield to a solution such as the one presented.

*The Bristol Company, Waterbury, Connecticut.

EXCLUSIVE

Instrument panel at the Jackson dispatching office. Indicating receivers are energized when the dispatcher dials the code assigned to a station; the transmitters at the station send the information signals along the telephone circuit to this panel board, where they are indicated. The system of "bulls-eye" lights tell what variable is being transmitted, which instrument to read, and where the measurement is coming from.



THE DISTRIBUTION SYSTEM OF THE Mississippi Valley Gas Company covers a large part of the state of Mississippi. The section of that distribution system described here involves the portion supplied with gas by the Texas Gas Transmission Company. It represents an area along the west side of the state, roughly from Greenville, Mississippi, north to the Tennessee border. Plans are under way to similarily equip other areas that are served by Mississippi Valley, but supplied by other pipe line companies.

The problem before the company was that of dispatching gas to the various companies and communities served, over a large, often inaccessible, area in the most efficient and profitable manner. This involved staying within an assigned demand (under a system-wide contract with their supplier), while still selling the maximum volume of gas possible.

In designing a distribution system of this scope, it is vital to plan the installations so as to obtain the maximum amount of useful and necessary information from the minimum number of metering points. The metering points chosen by the Mississippi Valley Gas Company, along with the functions measured at each, are shown on the map of the system.

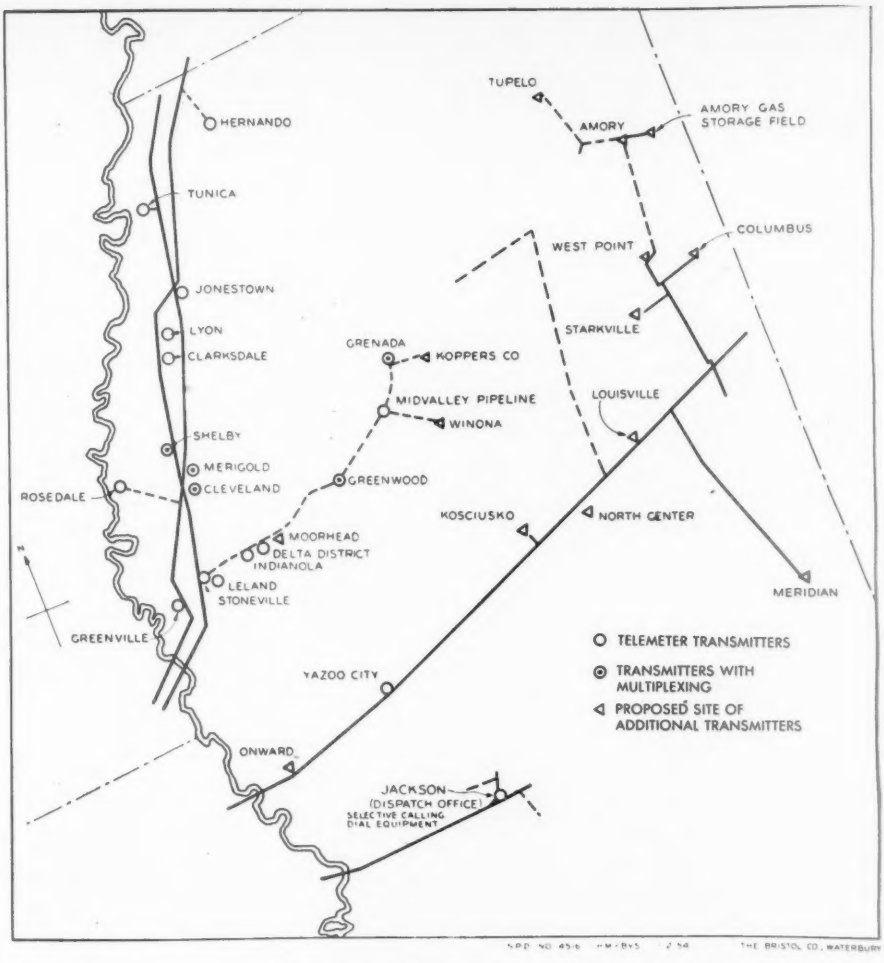
Once the measuring sites have been selected, the most difficult question to resolve is the method to be used in transmitting the measurements to the dispatching center.

If normal individual transmission circuits are used, the communication costs are prohibitive; therefore, achieving a justifiable figure for this cost loomed as a big problem. The two systems of communication that offered promise were microwave radio and leased telephone circuits.

After a careful study of the costs and advantages of each, it was decided to use a system of selective calling over leased telephone circuits. This proposal involved the rental of a single 0 to 15 cps long distance facility from Jackson to Memphis, Tennessee.

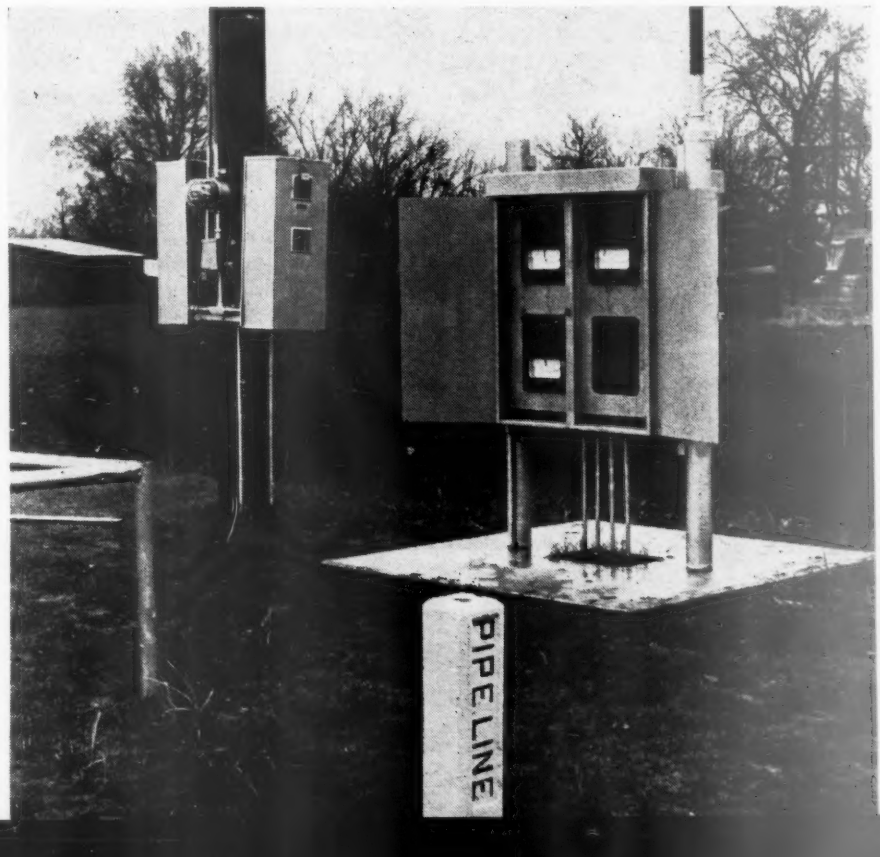
Local telephone facilities brought in the various measurement points to selectors along the circuit. The system of selective calling was worked out so that readings could be obtained from any measurement point by dialing code number from the dispatcher's office.

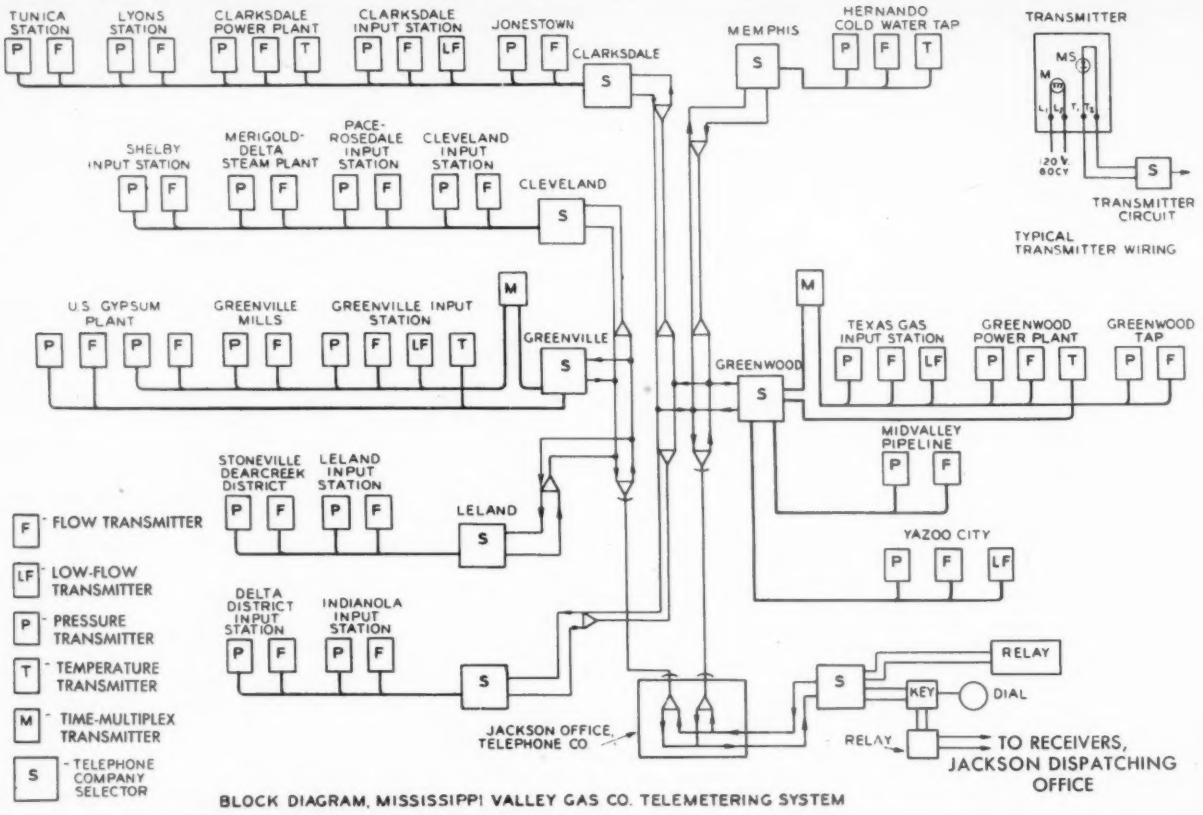
Although many selective calling telemetering systems have been installed previously, this system is unique in its number of points, their geographical distribution, and the communication facilities employed. In fact, the telephone company developed a new selector specifically for this job. The system as installed will handle up to 99



Distribution system of the Mississippi Valley Gas Company.

Typical metering point on the Valley Gas system, at Greenwood, Mississippi. The telemeter transmitters shown are measuring conditions in the pipe line that supplies the distribution system at this point.





BLOCK DIAGRAM, MISSISSIPPI VALLEY GAS CO. TELEMETERING SYSTEM

dialing points, and the number can be readily expanded as necessary.

As shown in the map, at present there are 49 telemetering transmitters installed, from which readings can be obtained by dialing the assigned code number. Remote control will be installed later at several points; this too will be actuated by the dialing system. The communication facilities are remarkably flexible, and additions can be made without any change in the equipment other than assigning new dialing numbers.

The measuring and telemetering system, as finally worked out by The Bristol Company, Mississippi Valley Gas Company, and Southern Bell Telephone and Telegraph Company, has a telemeter transmitter[1] installed at each measuring point.

This transmitter continually measures and transmits a timed impulse, which is proportional to the measurement, on a 5-second cycle. When the assigned code number of a particular transmitter is dialed, its measurement is indicated on the proper receiver at the dispatching office.

In order to reduce dialing time and effort, and to reserve selective calling points for expansion, time-multiplex equipment[2] was used at two points in the system. At each of these points, measurements are received from seven different transmitters; when the multiplex code number is dialed, the seven measurements are transmitted sequentially over the circuit with only one dialing operation. This series of readings can, of course, be interrupted as desired by the load dispatcher.

The instrument panel at the dispatching office bears seven indicating telemeter receivers, a multiplex receiver, and a number of relays and signal lights. (This panel is shown with a dispatcher at the dial.) When a code number is dialed, contact is made with the desired transmitter, and the following takes place:

1. The correct receiver is connected automatically to the line.
2. A light designating the town location of the transmitter is lit.
3. A light indicates what function is being measured, whether flow, pressure, or temperature.
4. A light inside the receiver in use is turned on and the reading is clearly indicated.

In this way, the dispatcher has a check on where the measurement is being made, what variable is being measured, and which receiver to read—an automatic check on errors in dialing.

The receiver remains connected to the transmitter in question, continuously indicating conditions at that point, until the dispatcher records the reading, depresses his key, and dials a code for another measurement.

With this system, all 49 points can be logged in about 15 minutes. Rapid calculations of load conditions are made with a special calculating board in another 15 minutes, leaving 30 minutes for spot checks of critical points or other dispatching operations before the next complete hourly survey of the system.

The operation of this dispatching system has been very satisfactory. The readings taken check the delivery figures of the supplying pipe line company very closely. The dispatching operations that have been made possible have been helpful in avoiding heavy demand penalties. Other benefits have been equally appealing. There is a power plant in the area that can make use of large blocks of gas during off-peak load periods. This system permits the dispatcher to predict when this gas can be supplied, and in what volume. This increases net sales without exceeding peak demand. Also, having the measurements at hand allows the dispatcher to direct the consumption of industrial users, who can revert to other fuel during peak domestic demand hours, when so directed.

This installation is the most complete and far-reaching system of selective calling yet installed. In the solution of the problems involved, new pieces of equipment were developed, new ideas and plans of installation and operation were involved, and a new system of communication was designed and built. * * *

[1] Bristol Metameter transmitter.
[2] Bristol.

One of two Western Gear Works speed reducing units in the new ammonia plant of Brea Chemicals, Inc., Brea, Calif., a subsidiary of the Union Oil Company of California. The units are driven by Elliott Steam Turbines at 3600 RPM input, delivering 1250 HP at 300 RPM output to drive Cooper-Bessemer reciprocating hydrogen compressors.

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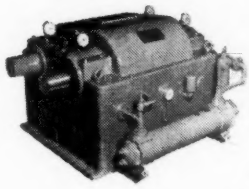
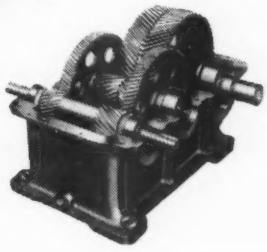


Custom-modified high speed unit



Parallel shaft speed reducer

When progressive companies design and construct pumping stations, they almost invariably specify Western Gear speed reducers or high speed units for pumping applications. Because they know that Western Gear, with 66 years of experience in the manufacture of power transmission equipment, can be relied upon to build units that perform with unfailing dependability and utmost efficiency.

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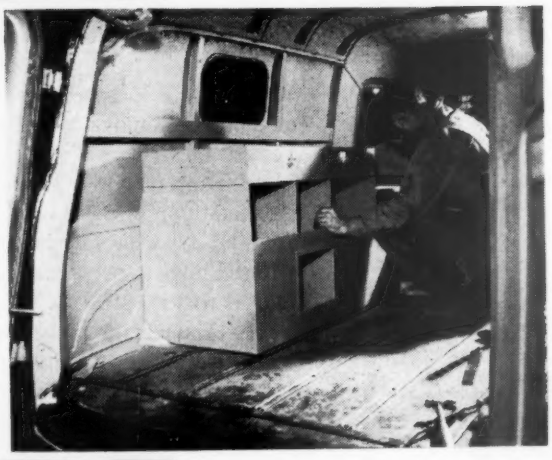
office-laboratories on wheels

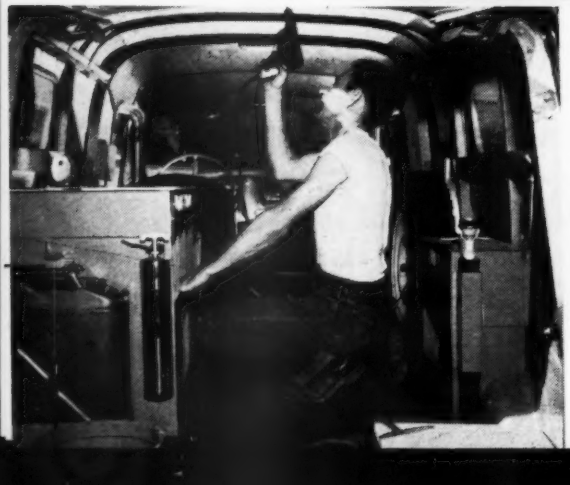
Everything from pencil-sharpener to desk is built-in equipment in these remarkable vehicles used by Service Pipe Line gagers

Dal Clark

Office: Gager Tom Wilson, Shawnee, figures his run tickets while waiting for a tank of oil to run out.



Cabinets, shelves and holders are fabricated by Service's machine shops personnel, then placed in the panel trucks in sections. When all equipment is installed, truck will be complete down to a folding stool for the gager to sit on while working at the desk shown being installed in this picture. Trucks were designed by company personnel and all work is done by them.



Finishing touches are added by a company carpenter just before the truck is ready for delivery. Everything is arranged for safety and convenience. Platform, right foreground, will hold gager's centrifuge.

WHEN the weather's bad a gager can't get in the trunk of his car and grind out the oil," gager Arthur Richmond said, "but you can get inside this baby." He pointed with pride at the panel gaging truck furnished by Service Pipe Line Company.

Richmond was expressing one of the many reasons he and the other gagers like the new trucks that are being furnished to all the company's 150 district gagers.

In addition to getting the gager in out of inclement weather during part of his routine, the trucks have a number of advantages as pointed out by the gagers themselves when they made their written reports on the vehicles:

(1) **It eliminates the necessity** of the gagers owning two cars for which they had to buy licenses, insurance, repairs, etc.;

(2) **Good producer and public relations.** Gagers reported the trucks gave the producers and public a much better impression of Service Pipe Line, always a desirable goal. The producers felt the company was giving its gagers the best possible equipment to make the necessary tests on their oil. The trucks are also easy to identify in case a producer, or a landowner, needs to find a company representative in a hurry;

(3) **The built-in office** (desk, chair, and compartments for pencils and other supplies) enables the gager to work on his run tickets while a tank is pumping out. Formerly, he lost time while he sat in his car and waited for the tank to empty;

(4) **A fourth gear** not found on standard automobiles, and higher wheels, helps the gager complete his rounds even though the roads are covered with mud and snow;

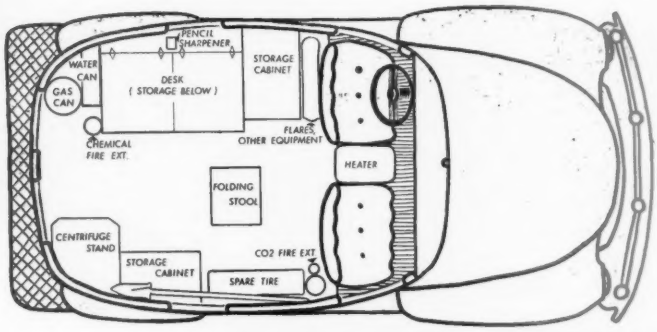
(5) **The trucks are ready to go** at all times with the gaging equipment and books in place. When the relief gager takes over he doesn't have to change equipment from the regular gager's car to his and perhaps miss something.

Over a year ago, the company furnished Richmond and several other gagers in Oklahoma and Wyoming with the panel trucks especially designed for their use. They were equipped with a built-in desk, storage cabinets, fire extinguishers, in fact, everything the gager might need on his job, including a pencil sharpener and a shovel (see sketch).

EXCLUSIVE

Roof includes vent and identification markings for patrol pilot. Vent, added by shop personnel, allows crude oil fumes to escape that otherwise might make the gager ill when working inside. Service expects to have all 150 district gagers equipped with the modern trucks by the end of 1955.

Floor plan. Not shown are wall brackets for seals, soap, etc. Special heater goes with trucks assigned to northern states.



The company instructed the gagers to give the trucks a good tryout on their regular gaging runs, then submit written reports of their advantages, disadvantages and suggestions for improvements.

It didn't take long for the enthusiastic reports to come rolling in:

"I have been a regular district gager for 11 years, and this is the greatest help the gagers have received," one gager wrote.

"This panel is just better all around for gaging and covering roads on a gager's district than a low-built car would be," a Wyoming gager wrote. *"Also he has a lot of room to work inside out of the weather where it can be made nice and warm. In the winter time a gager must be warm and comfortable or he is not going to be too efficient."*

There were many other comments—and suggestions for improvements. They suggested such things as (1) side windows on the panels for better visibility when at crossroads or parked on streets, (2) desk top and other loose articles anchored so they wouldn't rattle, (3) placing the spare tire inside the panel, (4) tires with treads designed for mud and snow, (5) set the centrifuge higher off the floor so that it is easier to reach, (6) install a larger rear vision mirror inside the cab.

The company carefully studied all suggestions and adopted the most practical ones.

By the end of 1954, the company issued some 90 trucks and plans to have all 150 district gagers supplied by the end of 1955.

Service buys standard panel trucks with four-speed transmissions, then turns them over to the Tulsa shops for modifications. Shop technicians bolt in the metal desk and tool box fabricated by shop welders, and install overhead lights, extra windows, a vent in the ceiling, racks for fire extinguishers, gasoline can, and other equipment.

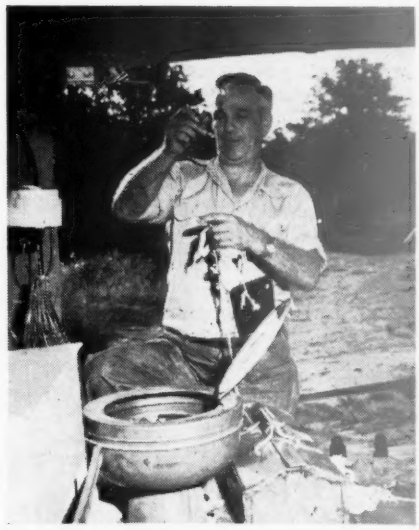
Trucks assigned to western Kansas, Wyoming, and North Dakota are equipped with an extra heater, a 50,000 Btu gasoline unit that is thermostatically controlled and self-contained.

Trucks assigned to remote areas are also equipped with two-way radio.

When the trucks roll out of the shops with the last bolt and tray in place, they are truly laboratory-offices on wheels.

Even the wives are enthusiastic about the trucks. As one of them wrote in, "Now, we can have a personal car that doesn't have oily seats and smell like crude oil."

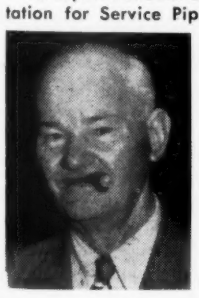
* * *



Laboratory. District gager Tom Wilson, Shawnee, prepares to grind out an oil sample.

Windows in the panel were suggested by a gager during tryout of the gaging truck, and adopted by the company for greater visibility.

The Author



As superintendent of motor transportation for Service Pipe Line Company, Dal Clark's duties include the procuring of cars, trucks, and trailers for the entire organization.

Dal was driving a horse-drawn fire engine in his home-town of Durant, Oklahoma, in 1916, when the city converted to motorized equipment. He was placed in charge of maintenance on the fire trucks, and has worked with motor vehicles in one capacity or another ever since.

He joined his present company during the Ranger boom in 1918. He is a charter member and president of the Petroleum Motor Transport Association.

Fundamentals of Corrosion Surveys

- Gathering Data
- Types of Tests
- Evaluating Tests
- Determining Damage
- Planning Protection
- Costs and Economies

Marshall E. Parker

A survey has been defined as a "critical inspection to obtain exact information." The corrosion survey is an inspection made of a structure and its environment, using suitable instrumentation, to obtain certain information — not necessarily exact — which is relevant to the corrosion of that structure, and to steps that may be taken to avert or mitigate that corrosion.

The particular set of data that will be taken is determined partly by the particular question whose answer is being sought. Among the questions to which a corrosion survey may be directed are:

(1) Is the structure subject to corrosion by its environment?
(2) How severe is the exposure?
(3) Is the attack (actual or anticipated) distributed or concentrated? If concentrated, where?
(4) How much damage has been done by corrosion.
(5) How rapidly is corrosion progressing now?
(6) What can be done about it? At what cost? With what savings?

These are all general questions; there will inevitably arise, when a specific survey is planned or while it is in progress, other and more specific questions whose answers must be sought. And, inevitably, there will remain after the survey has been completed, other relevant questions whose answers have not been found; we will either substitute estimates for these, or we will put into our designed protective systems a margin of safety sufficient to overcome the uncertainties. As we are concerned with a problem in engineering, rather than in basic science, the economic factor is important. Often the margin of safety costs less than would the detailed survey that might eliminate its necessity.

EXCLUSIVE

Gather and Study Data

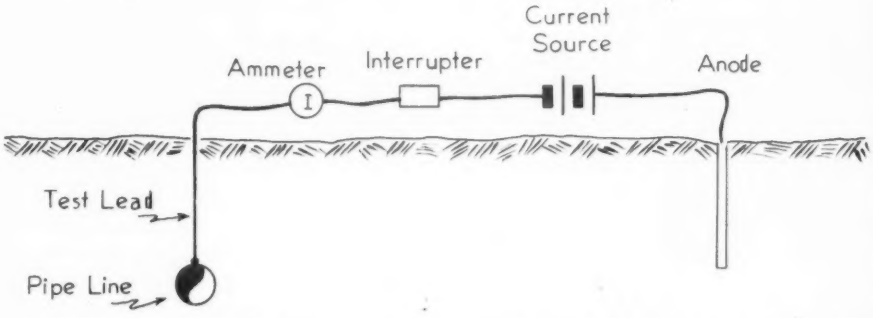
One element of importance to any survey is the gathering and study of available data on the system; maps, previous surveys, leak records, coating specifications, and other records should all be studied carefully. This effort will be repaid both by the actual facts so discovered, and by the time savings made possible by a greater degree of familiarity with the system when field work is actually begun.

Not to be overlooked as a useful source of information about a structure is the experience of the men who have been operating it and taking care of it. Useful experience in this category is by no means limited to the engineering personnel, nor to those who are supposed to be the record-keepers. Very often the foreman and laborers, the men in the ditch, can give information of great value. Such information, of course, should be carefully evaluated, and accepted only if verifiable; and usually it will require some degree of translation into more generally accepted terms than those in which it is communicated.

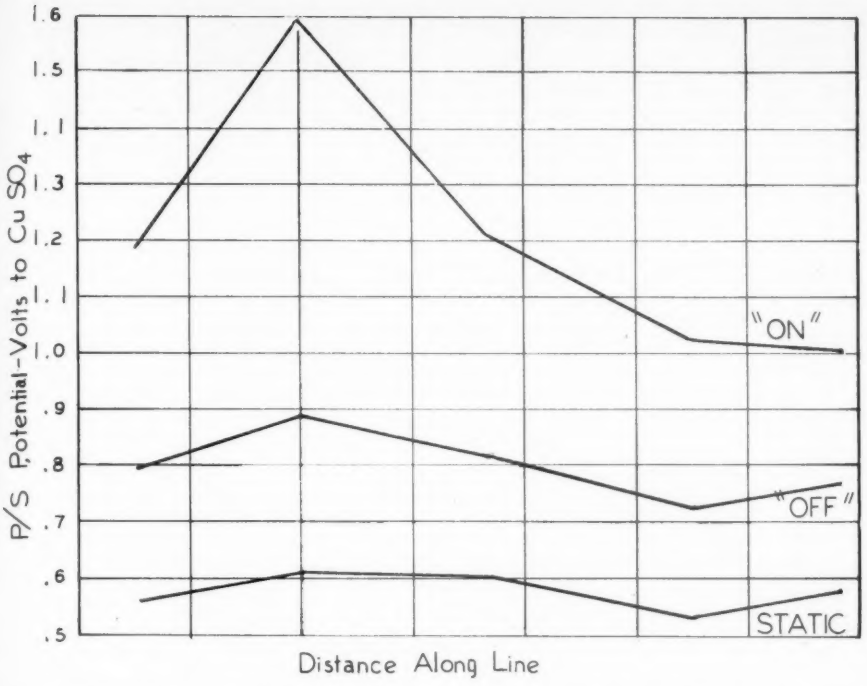
It is particularly important to note that an opinion to the effect that a certain pipe line is "all eaten up" or "as good as new" is necessarily based on the experience of the one making the statement; it is not uncommon to hear both of these things said about the same line. But if some idea of the actual number, location, and appearance of leaks can be obtained, this is usable data.

Plan Necessary Action

Before beginning the field work proper, it is well to formulate a plan of action. This will largely be based on the primary purpose of the survey, and will be influenced by the facilities and manpower available, by the ease or difficulty of access to the site, and by the degree of knowledge already at hand about the structure. It is a serious



(1) Instead of test lead shown, connection may be made to a valve or riser above ground. Contact bar is not recommended. (2) Shunt and voltmeter may be used instead of ammeter. (3) Automatic (battery-powered interrupter) may be used, or the current can be interrupted manually. (4) Current source may be welding machine, battery charger, storage battery, or dry cells; sometimes current can be "borrowed" from an adjacent protected structure. (5) Anode may be driven rods, pipes in augered holes, aluminum foil, or an existing structure; magnesium or zinc may be used, combining the anode with the current source.



Plot of observed values. Static potential (before application of any test current), and potentials with current both "off" and "on" are plotted, using a linear vertical scale. All potentials are with respect to a copper-copper sulfate electrode.

mistake, however, to place too much emphasis on this plan of action, and to follow it blindly, uninfluenced by actual conditions encountered. The corrosion engineer must be ever alert to unanticipated conditions, and prepared to follow lines of investigation not previously planned.

The questions of what measurements to make, and of the frequency or spacing of these measurements, can best be discussed separately under the classifications of the structure being surveyed. Techniques of making the measurements, and the instrumentation to be used, are outside the scope of the present discussion. All of the surveys here discussed will be those having to do with corrosion by soil and soil moisture; of structures exposed to these conditions, pipe lines are by far the greatest single class.

Existing Pipe Line — Coated

In the majority of cases, a survey conducted upon an existing coated pipe line seeks the answer to one fundamental question — how much current will be required to place the line under cathodic protection? Subsidiary questions have to do with such details as the type of protective system which can best be used, the distribution of current drainage points, and the handling of interference effects with other pipe lines and structures in the vicinity.

Preliminaries. A study of the maps and other available information concerning the line and its location may indicate some possible sites for setting up a current requirement test. If the line has been in existence long enough to have experienced leaks, location of these is a good indication of the type of soil most suitable for anode sites. If test leads have been installed, their locations should also be considered. In the absence of any other guides, a reconnaissance trip over the line, or over roads that cross it, should be made. Measurements of soil resistivity may be taken at possible sites, if necessary. The location chosen should be one that has reasonably low resistance soil (to simplify the temporary ground bed needed for the test), and which is readily accessible for the installation of the test equipment.

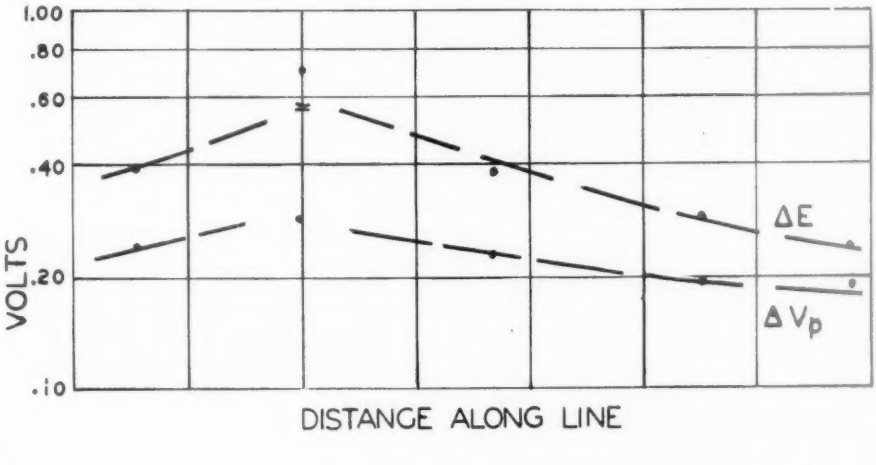
Current will be drained from the line at the chosen site for a period of several hours. The amount of current will depend upon the length and diameter of the line section under test and upon the excellence of the coating; it may vary from as little as 10 milliamperes to as much as 100 amp. Before setting up such a test, it is obviously very helpful to have some kind of idea as to the amount of current which will be needed.

First-class coal-tar coatings, when relatively new, may vary from an equivalent 1 per cent bare to as low as 1/20 per cent bare. Older coatings of the same kind may go as high as 5 per cent; still older coatings, and those of older kinds of enamel, without reinforcements, run as high as 20 per cent, extremely poor coatings as high as 50 per cent. Taking 2 milliamperes per square foot as the current required for bare pipe, and an assumed value for the coating, it is easy to arrive at a good guess for the amount of test current to use. It is always good practice to make the first test with a current as low as is likely to be effective; the test can be curtailed and the current increased if it is inadequate.

Test Currents. For test currents up to about 1 amp, if soil as low as 500 ohm per cm is available, magnesium ribbon (Galvo-line) may be used as a current source. Up to 3 or 4 amp, a storage battery may be used as a booster for the magnesium. For higher values, it is convenient to use a welding machine and a temporary ground bed. The latter may occasionally consist of some abandoned structure with a large contact area with the soil. If something of this kind is not at hand, short lengths of scrap pipe may be set in augured holes filled with salt water.

Considerable success has been had recently with aluminum foil, purchasable at any grocery store. This is simply rolled out on top of a wet, bare soil surface, and weighted down. Contact

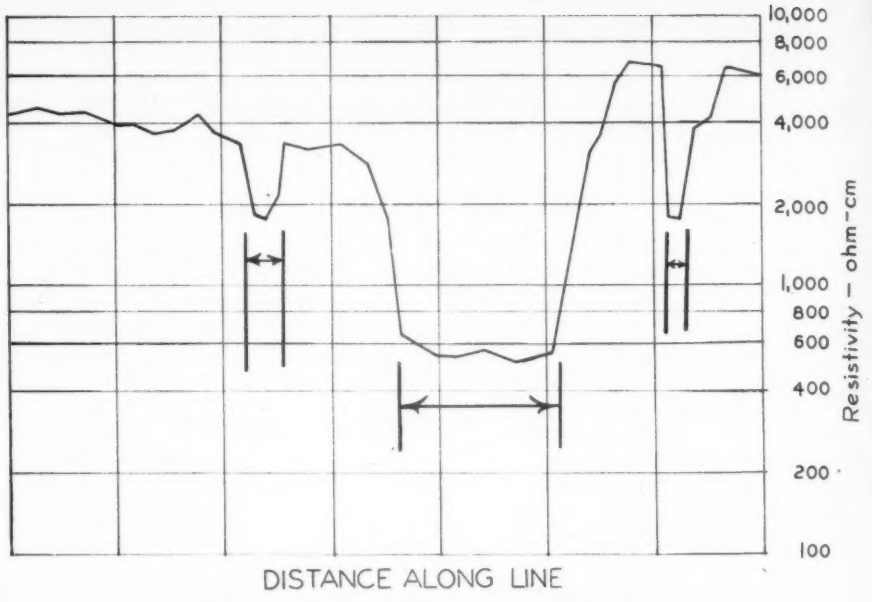
Derived potential values. Driving voltage ("on" - "off") and polarization potential ("off" - static) are plotted on a semi-logarithmic scale, against distance along the line (linear).



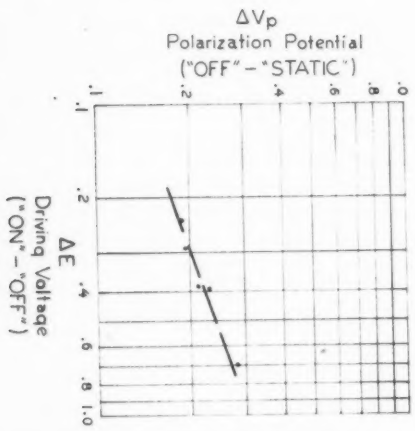
can be made by laying a bare wire along the length of the foil. Regulation of current output, when a welding machine is used, is more easily accomplished by controlling the resistance of the ground bed.

Static Potential Readings. Prior to the drainage of any current from the line, a set of "static potential" readings should be taken. There are merely the pipe-to-soil potentials at a number of points along the line, uninfluenced by any drainage current (these must be taken before the test; polarization will change the values after the test.) The spacing must be determined by the expected spread of the test current, and should be such as to give at least three or more readings on either side of the drain point (unless the latter is near the end of a section.)

It is better to have more static readings than needed, than it is to have too few. If the line has test leads, a static reading should usually be taken at each



Soil resistivity survey on bare line. "Hot spots are indicated, as described in text.



Functional relationship between derived values. Polarization potential is plotted as a function of driving voltage, using logarithmic paper.

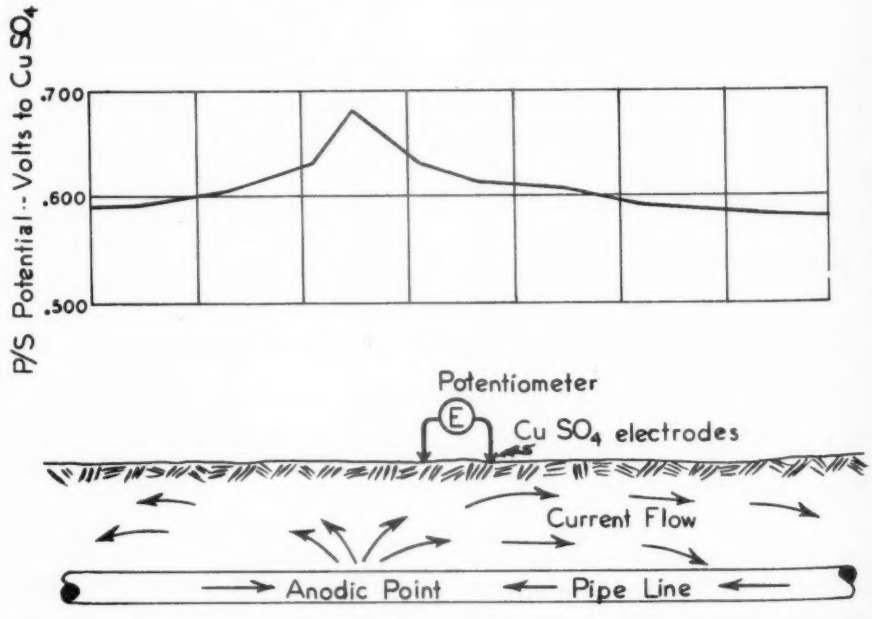
one. Do not omit to take readings on each casing also, so that shorted casings may be spotted. This preliminary survey can well be combined with the reconnaissance mentioned above.

Current Interruption. The current drained should be interrupted, either mannually or by the use of an automatic interrupter. The "on" period should, in general, be longer than the "off" interval; 45 sec on and 15 off is a convenient timing. The 15 sec off period is long enough for the balancing of a potentiometer, and the entire cycle is short enough that little time is lost in waiting.

As soon as the interrupter is operating, a quick check should be made at the drain point, and at least one other point down the line, to get an idea as to the adequacy of the current being drained. If it is insufficient, there is no point in completing the test at this value; the current should be increased at once. As soon as a satisfactory value is reached, the test can begin.

It is better to allow two or three hours for polarization before taking a final complete set of readings; nevertheless, the pressure urgency is often such that readings are begun at once; and it must be admitted that the results are little influenced by this procedure. The most distant point can be checked first; this will allow the maximum polarization time before the first reading. At each point two readings are to be taken, corresponding to the "off" and "on" conditions respectively. Normally, on coated lines, the electrode can be placed directly over the line; a remote electrode is useful only in making certain special tests, and is *never* a valid criterion of cathodic protection when considered alone.

The three potential readings taken at each point, together with the values of the current used, enable the engineer to compute the current demand of the line section, for any applicable criterion of cathodic protection. It is useful to maintain a constant value of the current drained; if this is not feasible, then readings of the actual value should be made at several spaced intervals during the test, and a plot of current vs. time will make it possible to estimate



Location of anodic area by surface potentials. A starting potential is obtained by direct reference to a point of contact to the line, and subsequent values derived by algebraic addition of observed differences. As can be seen from the figure, a peak is indicative of current discharge from the line, i.e., an anodic or corroding area.

the actual value flowing at any specific time.

The potential readings are reduced to two potential differences; the "on" value minus the "off" is the driving voltage, and the "off" minus the static is the polarization potential. The latter is a function of the driving voltage and the time; the actual total pipe-to-soil potential reached at any point is the sum of the driving voltage (which may be the sum of two effects from two drain points) and the polarization potential, added to the static potential. Thus it is possible to predict the total potential at any given point under any combination of drainage values from various sources.

Locating Permanent Drain Points. The other data that should be obtained when conducting this type of survey consists of determining the proper location for the permanent drain points. The procedure here will be determined by the choice of method; if galvanic anodes are to be used, many small drain points will be needed. If the choice is rectifiers, it is seldom wise to attempt a complete design on the basis of a field survey; the final design is best cut to fit the field when the installation is made.

If rectifiers are to be used, the considerations for the selection of each site are as follows:

(1) Availability of power.
(2) Low resistivity soil.
(3) Accessibility.
(4) Correct spacing along the line.

These have not necessarily been named in order of importance; the decision is always based on economic considerations, and is actually outside of the scope of a survey as such. Data relevant to the four factors named must be taken during the survey, but the decision is ultimately made later, and includes factors not at hand at the time of the survey.

Existing Pipe Line — Bare

The approach to a bare pipe line is entirely different from that to a coated line. In the case of a bare line, it is rarely justifiable economically to attempt the complete protection of the line; usually it is found that the application of "hot spot" protection, involving 10 or 15 per cent of the current required for complete protection, will eliminate as much as 90 per cent of the corrosion. With a coated line, on the other hand, the meticulously detailed survey which would be required to give each part of the line *exactly* the amount of protection it needs would cost more than would be saved by so doing.

Locate Hot Spots. The problem, then, resolves itself into that of locating the hot spots. There are two ways of doing this; by means of a soil resistivity survey, which shows the spots where corrosion is likely to be occurring; and by a surface potential survey, which shows the spots where corrosion is occurring. The superiority of the latter is not quite so great as the description would imply; it is slower and more expensive, and is not always easy to interpret.

Soil Resistivity Survey. The soil resistivity survey is based upon the premise that the resistivity of the soil in which a pipe lies correlates with the corrosiveness much more closely than any other easily measureable variable. It is most effectively conducted with an instrument which uses the four-terminal method, thereby permitting the determination of the resistivity to the approximate depth to which the pipe is buried.

Most commonly, an electrode spacing of five feet is used; the actual spacing is set at 5 ft, 2½-in, which gives a multiplier of 1000. Readings are taken at intervals, and the location of the probable hot spot is determined by inspection of a plotted resistivity profile. It is difficult to prescribe definite rules for the spacing of readings, but the following may be found useful:

(1) A reading should be taken every

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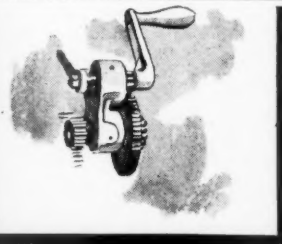

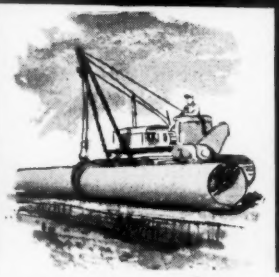

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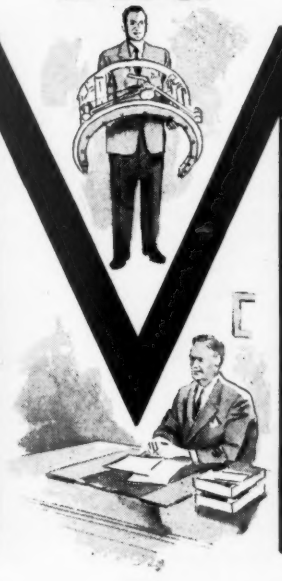

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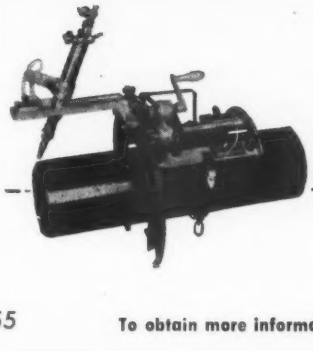

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300 ft under any circumstances.

(2) A reading should be taken whenever surface appearance indicates a possible change in the soil characteristics.

(3) If the reading obtained, operating under the first rule, is markedly different from the preceding one, a reading should be taken back along the line of progress, to locate the point of change.

In determining the hot spots from the plotted profile, the folowing principles may be used as a guide:

(1) Soil over 10,000 ohm per cm is rarely corrosive, except when it occurs as a narrow band between soils of much higher resistivity.

(2) Soil under 1,000 ohm per cm is almost always corrosive, except when it occurs as an isolated strip between soils of lower resistivity.

(3) Soils between these two values are only corrosive in narrow strips of relatively low resistivity.

As has been pointed out, this type of survey is prinicipally useful in locating areas in which the soil is likely to be corrosive. If it is desired to locate the areas in which corrosion is actually taking place, it is necessary to detect the evidence of current flow to and from the pipe; this may be done by the method of surface potentials.

Surface Potential Survey. In a surface potential survey, two copper sulfate electrodes are used. Basically, the survey consists of measuring the difference in potential between two electrodes placed over the line at a standard distance apart; ordinarily, 20 to 30 ft may be used. Evidence of current flow in the soil away from a given point is taken as being an indication of current flow from the line at that point, i.e., as evidence of an anodic center. In order to locate these anodic areas more precisely, closer spacing should be used; but, to keep the records in orderly and usable condition, the basic record must consist of readings taken at a uniform spacing.

If the soil resistivity throughout a line were uniform, these surface potential differences would be truly proportional to the current density in the soil. The value of the potential read, however, will be profoundly influenced by the soil resistance between the two electrode positions; in high resistance soil, a difference of 100 mv may be indicative of only a negligible amount of current, whereas in low resistance soils, 10 mv may indicate a serious anode. It is this factor which makes the interpretation of surface potentials a matter requiring a considerable degree of skill and experience. It is not too difficult to locate the anodic points, for these can be found by merely considering the *direction* of the potentials; but the evaluation of their relative intensities is more difficult, since it involves their magnitude and the soil resistivity.

Congested Systems — Single Ownership

Often the corrosion engineer will be called upon to make a comprehensive survey of a plant area, such as a refinery, in which there are numerous pipes of a very considerable variety of material, coating, and function, but all under a single ownership and control. In such a case the problem is that of determining first, whether cathodic protection is necesary or not; secondly, whether it is feasible; and finally, how much current will be required and how it must be distributed.

In the discussion under coated lines, it was not recommended that a complete survey of soil resistivities be made; but in this case such a survey is strongly recommended. This is important for several reasons: first, a general knowledge of the resistivity is of value in estimating the probable average severity of attack; if it becomes necessary or advisable to consider cathodic protection, this factor is important in determining both the type (galvanic anodes or impressed current) to be used and the distribution; and finally, the systematic coverage of the entire site with a

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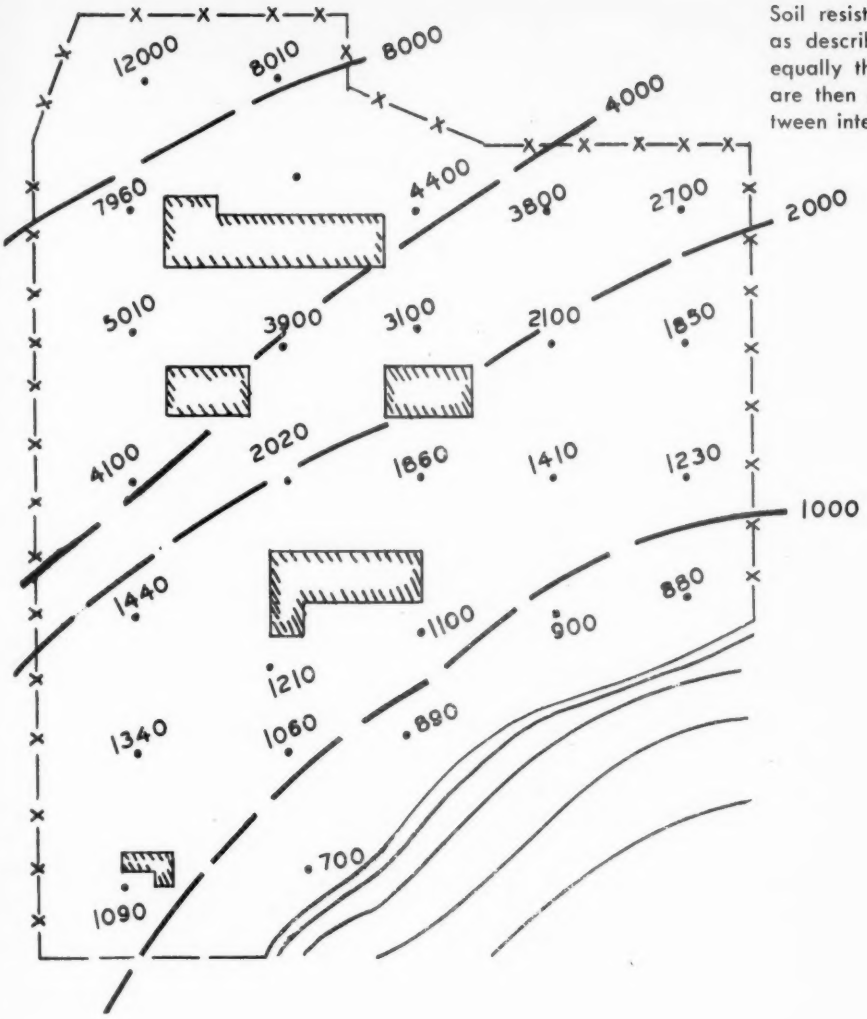


Soil resistivity plat of area. Readings are taken, as described, at points spaced approximately equally throughout the area. Equi-resistivity lines are then drawn, using a logarithmic spacing between intervals.

four-terminal resistivity apparatus enables the engineer to familiarize himself with the general layout, and affords him the opportunity to observe any specific conditions which merit further investigation.

The first step in such a survey, then, should be an overall soil resistivity survey of the area. Readings should be spotted at such intervals as will give a reasonably good picture of the total variation within the site; a maximum spacing of 3000 ft is recommended, with closer intervals where the variation is extreme. These data should be plotted on a contour type map, showing the variation over the entire area.

The intervals used for contouring should be logarithmic; e.g., 500, 1000, 2000, 4000, and 8000 ohm per cm — extended as far in either direction as needed to cover the range found. The ratio indicated, 2:1, will be found satisfactory for most cases; occasionally a 4:1 ratio may be employed, but it is rarely advisable to use one more closely spaced.

The next step should ordinarily be the running of one or more current requirement tests, very similiar to those described under coated pipe lines. It may be more difficult to arrive at a satisfactory value for the test current, and the interpretation of the results is sure to be more complex. Among the complicating factors that are likely to be encountered are the presence of poorly conducting or insulated joints, such as mechanical couplings and bell-and-spigot joints in cast iron pipe.

The Author

Marshall E. Parker heads the Cormit Engineering Company, Houston, Texas.

He has been engaged in the practice of corrosion engineering as a consultant, and this recently organized company is designed to broaden the scope of his activities. Consulting, surveys and design are supplemented by facilities and personnel to make comp'ete installations of cathodic protection systems. Parker has a BS from Rice Institute, and is a registered professional engineer in Texas. He has been associated with Pan American Pipe Line Company and Cathodic Protection Service.

It will not be possible to interpret either polarization potential or driving voltage as a simple exponential function of the distance from the drainage point, as is the case with a long cross-country pipe line. It is helpful to plot both of these values on maps, drawing contours representing equal increments of the variable, in order to visualize the results. It is also advisable to plot a graph showing polarization potential as a function of driving voltage, preferably using logarithmic paper.

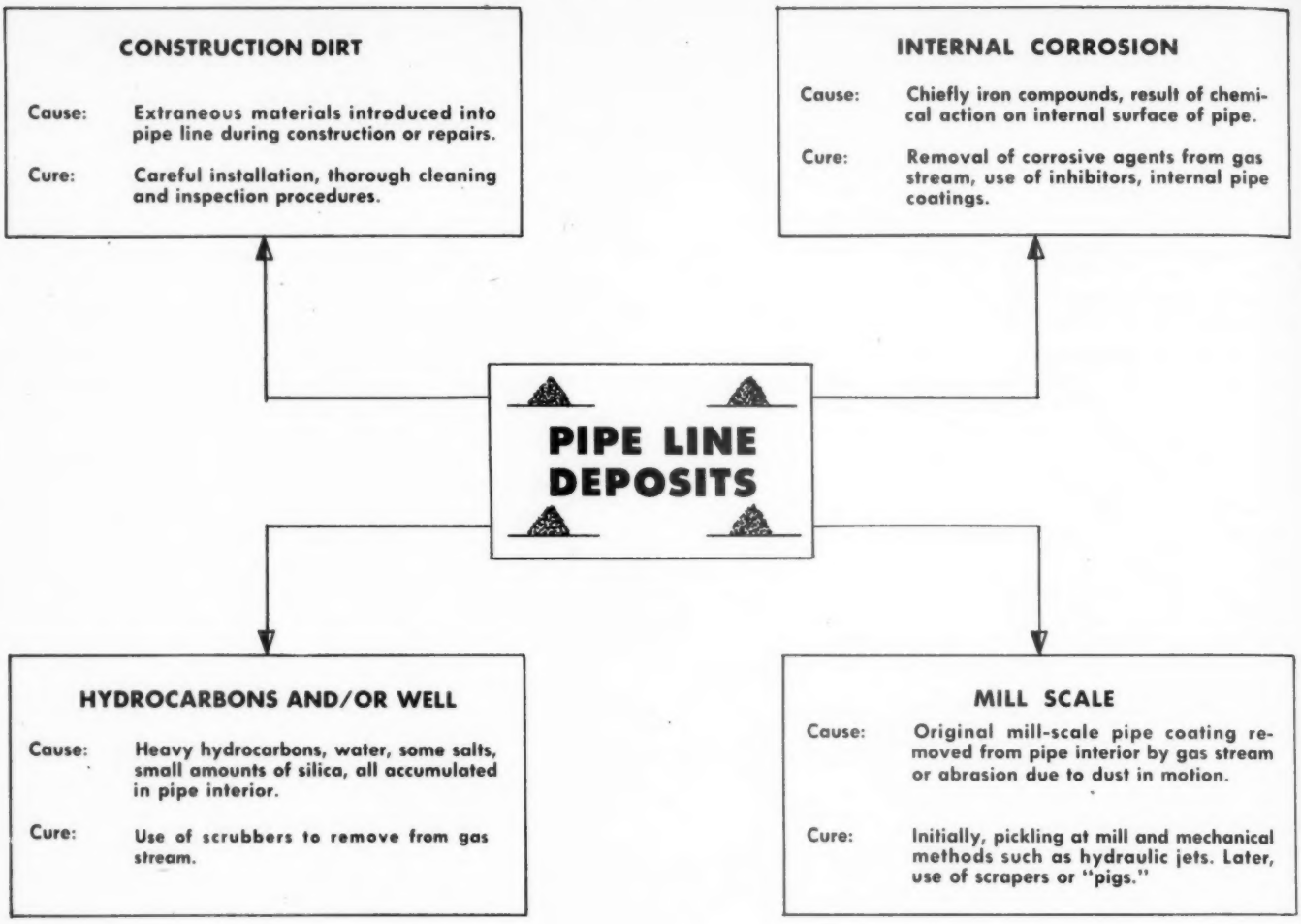
This will not ordinarily be a simple function, because of the difference in the behavior of the various kinds of pipe surfaces, but more of a "scatter diagram" from which only a rough correlation can be drawn. Even this rough correspondence, however, will be found most useful in predicting the results to be obtained from installed drainage systems.

Other Types of Surveys

There are many possible kinds of corrosion surveys that cannot be discussed because of space and time limitations. There is the stray current survey; the survey of a distribution system or portion thereof, surrounded by many structures of foreign ownership; and there are many highly specialized surveys, made to check the performance of a particular kind of coating, or a system of protection, or for some other specific purpose.

The interference survey is an important one in this group. Once a cathodic protection system has been installed and placed in operation, there remains the responsibility of seeing that it does not inflict damage upon the structures in its vicinity. To conduct such a survey, it is usually proper to contact the representatives of such structures, so that they may participate in the study.

Often it will be found that the owners do not have corrosion engineers in their employ, and frequently they are quite willing to leave the entire responsibility up to those installing the system. It is impossible to set out rules for procedure in such cases, but the conscientious engineer will always remember that one of the basic principles of the engineering profession is the inherent responsibility of the individual practitioner to his employer, to his profession, and to society as a whole. The interests of the employer should never be permitted to overshadow those of the other two. * *


CONSTRUCTION DIRT
Cause: Extraneous materials introduced into pipe line during construction or repairs.
Cure: Careful installation, thorough cleaning and inspection procedures.
INTERNAL CORROSION
Cause: Chiefly iron compounds, result of chemical action on internal surface of pipe.
Cure: Removal of corrosive agents from gas stream, use of inhibitors, internal pipe coatings.
PIPE LINE DEPOSITS
HYDROCARBONS AND/OR WELL
Cause: Heavy hydrocarbons, water, some salts, small amounts of silica, all accumulated in pipe interior.
Cure: Use of scrubbers to remove from gas stream.
MILL SCALE
Cause: Original mill-scale pipe coating removed from pipe interior by gas stream or abrasion due to dust in motion.
Cure: Initially, pickling at mill and mechanical methods such as hydraulic jets. Later, use of scrapers or "pigs."

Gas Pipe Line Deposits . . .

. . . causes and cures

L. T. BISSEY

DUST deposits are found in varying amounts in pipe lines and in equipment handling natural gas or manufactured gas. As removed from pipe lines and equipment, dust samples present a wide variety of appearances. Samples with color ranging from light brown through red brown to black have been received from various natural gas companies. Some have a clean appearance; some are oily or waxy in aspect. Some samples have the semblance of very finely divided particles, some are agglomerated in larger bodies, and others form rather soft chunks retaining the shape of the place from which they were removed. Some samples are odorless, some have a sweet aromatic odor, and others have a pungent mercaptan smell.

Many of the dust samples examined contained pebbles, welding residue, fibrous materials of different sizes and different origin, small pieces of rubber, cinders, and other extraneously introduced materials.

Dust in natural gas is responsible for numerous operating difficulties resulting from its deposition, abrasive action and, perhaps, corrosive action.

Dust may deposit in gate bodies and prevent complete closure or even fill up gate bonnets and harden so as to prevent gate operation. Accumulations of dust decrease the capacity of a line. Although this reduction in capacity may not be very serious in large lines, reductions in capacity of from 30 to 40 per cent and cases of complete stoppage of gas flow have been reported. Dust may fill up compressor cylinders, and may deposit on diaphragms of positive displacement meters and on the face of orifice plates causing serious deviations in gas measurements. These deposits may cause failure of automatic control valves and block pilot orifices.

The abrasive action of dust on equipment and instruments is evident. Such wearing action produces additional dust and provides a fresh iron surface for corrosion. This abrasion is partic-

EXCLUSIVE

ularly injurious, even causing failure of regulators, compressor valves, orifice plates, and pipe bends. Equipment may also be damaged by the corrosive action of dust where water is present.

Although the amount of dust may vary according to many circumstances, dust concentrations as high as 11 lb of dust per 1,000,000 cu ft of gas have been reported.

The harmful effects of dust in natural gas are generally realized and the control of dust has been recognized as an important problem by the gas industry. Equipment manufacturers have studied the problem, and apparatus for the removal of pipe line deposits are available. The removal efficiency, however, is dependent not only on the apparatus but also upon the nature of the dust and other factors controlled by pipe line operations.

At present, there are at least three common ways of removing pipe line dust:

1. **filters,**
2. **liquid scrubbers, and**
3. **centrifugal dry scrubbers.**

The first method is generally suited to small-volume transmission lines and distribution lines, and the last two are suited to large-volume transmission lines.

Liquid Gas Scrubbers

Present-day liquid gas scrubbers operate continuously using a light weight oil to remove the dust and to pick up heavy hydrocarbons from the gas stream. At the bottom of the scrubber is an oil and sludge accumulator that may be blown and recharged with fresh oil. Above the accumulator is a gas-oil uniting zone, followed by a disengaging zone where the bulk of the oil is dropped out of the gas stream. Next, there is a secondary disengaging zone, and last, a mist extractor to remove the remainder of the oil. The entering gas mixes with the oil and flows upward. The oil wets the dust particles that are accumulated at the bottom by gravity.

The basic part of the dry centrifugal scrubber is a small cylindrical tube with a vertical inlet slot. The gas stream enters the slot tangentially and is given a circular motion. The dust particles are thrown against the sides of the tube by the developed centrifugal force, and then fall down through a discharge cone. A group of these tubes constitutes the scrubber itself.

With the picture of the dust problems in mind, and having considered current industrial dust removal practices, the investigators and the sponsors felt that a study of the deposit sources and properties might throw some light on possible preventive measures or on a more efficient use of the dust removal equipment. The ideal solution to the

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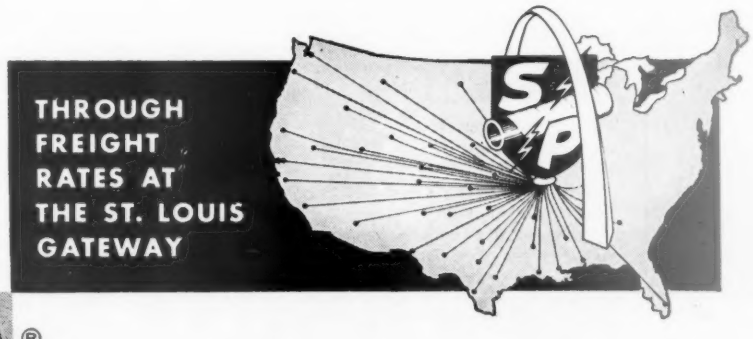

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problem would be the prevention of dust formation but, as yet, no successful method has been found.

Experimental Work

The experimental work consisted of screen analysis, mineralogical examination, magnetic separation, and chemical analysis. Forty-three samples of pipe line deposits were examined. All but one sample were from natural gas lines, and that sample was taken from a manufactured gas line. Specific compound mixture compositions were calculated for 27 deposits; in most cases, these compositions were fairly well substantiated by the total composition, agreement of calculated and determined ignition loss, and mineralogolical examination.

The outstanding anomaly of this investigation was the first deposit analyzed; this was the only natural gas pipe line deposit in which iron oxides were not the predominant compounds. It was a very light cream colored, finely divided powder taken from a service line, and it analyzed about 99 per cent tetrahydrated ferrous sulfate.

Conclusions

From the physical and chemical studies of natural gas pipe line deposits, the following conclusions can be drawn:

1. Evidence indicates that the sources of these deposits may be summarized as being:
   - (a) *Internal corrosion of the pipe line system. (Compounds, chiefly of iron, resulting from chemical action occurring on the internal surface of the pipe.)*
   - (b) *Mill-scale. (Original mill-scale pipe coating removed from the interior of the pipe by the gas stream or abrasion due to dust in motion.)*
   - (c) *Construction dirt. (Any extraneous material introduced into the pipe line system during construction or repairs.)*
   - (d) *Formation or well. (Heavy hydrocarbons, water, some salts and small amounts of silica.)*
2. In general these deposits are composed of three different chemical groups: silicon compounds, hydrocarbons, and iron compounds. Samples with high silica content may be considered as at least partially resulting from construction dirt. Hydrocarbons may form an appreciable percentage of the dust weight and probably result from organic materials accumulated in lines from manufactured gas, or incomplete separation of higher molecular weight hydrocarbons from the produced gas, or lubricants used in the system. Iron compounds without exception constitute most of the dust weight, and except for mill-scale they are the products of internal corrosion of natural gas pipe lines.
3. Magnetic fields attract dust particles. The magnetic properties of the dusts are related to the type of iron compounds existing in the samples.
4. Composition and particle size distribution of the dusts and the type of line (field, transmission, or distribution) from which the dust samples were taken are independent factors and do not bear any relation to one another.

The Author

L. T. Bissey is a member of the staff of the Department of Petroleum and Natural Gas Engineering of The Pennsylvania State University. A graduate of the University, Bissey received a BS degree in chemistry and a MS in fuel technology. He joined the University staff in 1936. Bissey is a member of the Eastern District Study Committee on Natural Gas Operating Practices of the API and chairman of Committee D-3 on Gaseous Fuels of the American Society for Testing Materials.

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5. A random distribution of particle size is predominant. In most cases the relative weight of particles larger than 250 microns was small.

6. A manufactured gas pipe line deposit included in this investigation has as its main constituent organic matter; the content of iron componds is lower and sulfur compounds higher percentage-wise than in natural gas deposits.

Suggestions

From the conclusions concerning the origin of pipe line dust, it follows that its elimination is possible only by controlling four main sources of dust; namely, corrosion, mill-scale, construction dirt, and heavy hydrocarbons.

The presence of water, hydrogen sulfide, carbon dioxide, and oxygen in natural gas is responsible for the internal corrosion of natural gas pipe lines. As the presence of very small amounts of these materials in the gas stream may cause extensive corrosion, the problem of the physical and economical possibilities involved in the total removal of these corrosive agents remains in question.

Other means of corrosion control are the use of inhibitors and pipe coatings. Corrosion inhibitors generally perform one or both of the following actions: (1) to make the pipe passive, and (2) to react with corrosion-producing compounds. In the case of internal corrosion of natural gas pipe lines there is need for a gaseous inhibitor whose reaction products are also gases. Aqueous solution inhibitors are not advisable due to the danger of hydrate formation or other operational difficulties.

Internal pipe coatings could be expected to control corrosion, but it would present an expensive and difficult solution in the case of pipe lines now in operation. Full benefit will be achieved only if the entire system is completely coated and dust free.

Pickling is the best method for removing mill-scale from new pipe but complete removal of the pickling solution is necessary if corrosion due to residual acid is to be avoided. Mechanical methods, such as hydraulic jets, for the removal of mill-scale will not completely remove the scale but will dislodge that portion that will readily flake off during normal operation of the line. Such incomplete removal should decrease the amount of mill-scale appearing in the dust yet some protection to the pipe may be offered by the remaining scale layer.

The possibility of total control of construction dirt exists by careful installation, thorough cleaning and inspection procedures during construction and repairs.

Conclusions concerning the use of magnetic fields as a method of dust removal were partially obscured by limitations discussed in the complete report of this work; however, the results indicate that magnetic fields deserve consideration as a means of controlling natural gas pipe line dusts.

Acknowledgments

The increasing importance of difficulties arising from natural gas pipe line deposits prompted the Pennsylvania Natural Gas Men's association to initiate a study by their fellowship at The Pennsylvania State University on this subject.

This work has been concluded and the information appearing in this article is a summary of the main points of the work. The complete report including experimental results is available in: "Natural Gas Pipeline Deposits" by L. T. Bissey and J. F. Villarreal, Mineral Industries Experiment Station Bulletin No. 63, College of Mineral Industries, The Pennsylvania State University, State College, Pennsylvania. (Price, $1.50.)

The authors of the report wish to express their thanks to the Pennsylvania Natural Gas Men's Association for their interest and support of this work and to the member companies who have furnished samples and information.

* * *

PUT YOUR
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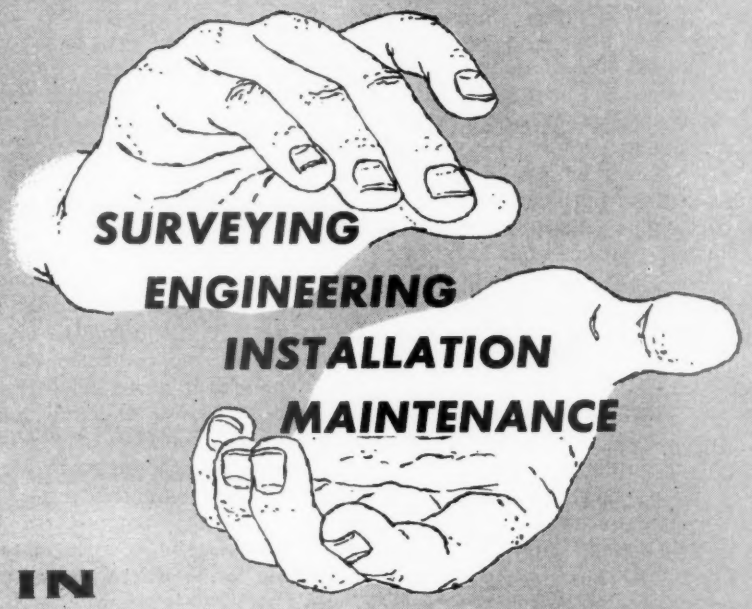

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Reference Electrodes: Where to Place Them

L. P. SUDRABIN and J. A. LEHMANN

A most perplexing problem often met by the corrosion engineer is the location of the reference electrode to establish the effectiveness of cathodic protection. This problem is emphasized by instances where (1) leaks develop on a pipe line even though a pipe-to-Cu-$CuSO_4$ reference electrode potential that is more electro-negative than — .85 v has been measured; or (2) conversely, if it is evident that the line is adequately protected at lower electro-negative potentials.

On a cathodically protected bare line the potential "seen" by the reference electrode usually varies with the position of the electrode relative to the pipe line. It is the intent of this discussion to develop a concept useful for determining the relation of the reference electrode location and the control of local and/or long line corrosion currents.

Cathode Polarization

Among the useful basic values is the protective potential of iron in soil established by Schwerdtfeger and McDorman[3] to be — .85 v measured against a Cu-$CuSO_4$ reference electrode. This is normally the open circuit potential of an iron anode in an airfree environment at pH of 9.0.

Brown and Mears[2] define cathodic protection as being complete when the cathodes are polarized to the open circuit potential of the anode E'_a.

EXCLUSIVE

Such cathode polarization[1] includes (a) the counter-emf by products formed or by concentration changes resulting from passage of current through an electrolytic cell, (b); the IR drop effects between the cathode and the electrical boundary of the protected corrosion cell expressed in terms of an emf, and (c), the activation potential required to drive an appreciable current through the interface where the electrode reactions may be inherently slow.

The protective potential (E'_a) and the polarized cathode potential may be expressed by the general equation:

$$(1)\quad E'_a = E_c + Ip\,(R_{cf} + R_{kc\rho})$$

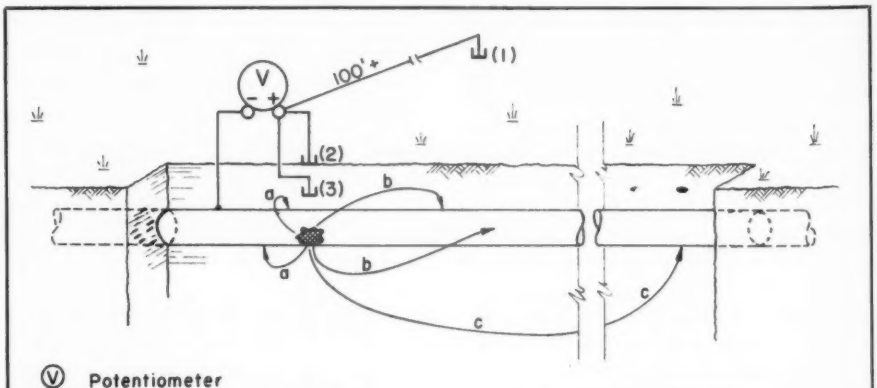
where:

E_c = cathode potential (closed circuit — including polarization effects a. and c.)
Ip = protective current
R_{cf} = resistance —(cathode film)
$R_{kc\rho}$ = resistance (soil contiguous with the cathode

It has been shown, in localized pitting, that the IR drop effect through the cathode component must be included in the cathodic polarization and that this form of polarization becomes increasingly important as the resistivity increases.[4] This form of polarization is characteristic for each corroding cell and is determined by its spatial conformation.

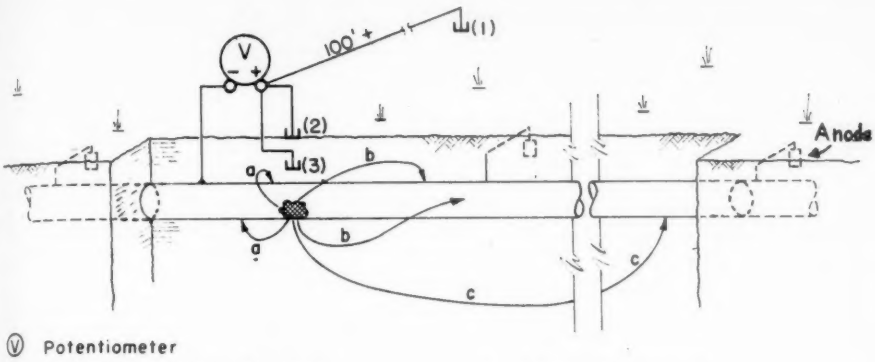
For a pit (anode) ½-in. in diameter, the reference electrode should be placed nearly ½-in. away from the adjoining bare cathodic surfaces at the electrical boundary of the protected corrosion cell to include all the polarization effect the system is entitled to. A potential of — .85 v measured to Cu-$CuSO_4$ reference electrode placed closer to the metal would result in over-protection since all the IR drop effect involved in the cathode polarization is not included. A reference electrode location outside this boundary will include an IR drop through the soil that has no effect on controlling the corrosion current and will result in only partial prevention of the localized activity. The latter situation may account for some reports that a pipe must be polarized to a potential more electro-negative than — .85 v to attain protection.

When the corrosion system anodic and cathodic areas increase in size or are spaced farther apart, the electrical boundary of the protected corrosion



Ⓥ Potentiometer
(1) Remote Cu·CuSO4 electrode
(2) Surface (over pipe) Cu·CuSO4 electrode
(3) Near pipe surface Cu·CuSO4 electrode
a. Local cell current
b. Intermediate galvanic current
c. Long-line galvanic current

FIG. 1. Cathodic protection of bare pipe (protective current from remote ground bed).



Ⓥ Potentiometer
(1) Remote Cu · $CuSO_4$ electrode
(2) Surface (over pipe) Cu · $CuSO_4$ electrode
(3) Near pipe surface Cu · $CuSO_4$ electrode
a. Local cell current
b. Intermediate galvanic current
c. Long - line galvanic current

FIG. 2. Cathodic protection of bare pipe (protective current from distributed magnesium anodes).

system tends to move away from the pipe line and a more remote reference electrode location may be used.

The preceding discussion implies that if you wish to stop long-line galvanic corrosion you can use a remote reference electrode position (100 ft plus). Such control may only reduce the localized pitting action on bare pipe lines (this pitting is more prevalent than commonly recognized even in some very high resistivity soils). This pitting may occur anywhere on the bare unprotected pipe surface and it can be particularly intense on areas otherwise generally cathodic.

The highly localized corrosion cells, having electrical boundaries close to the pipe, are often not detectable by ground surface potential measurement.

Potential Calculation

To calculate the pipe potential to some desired location over the pipe center axis when the potential at the ground surface is known, the following formula may be helpful. It should be recognized that the accuracy with which this equation may be used is limited by the reliability and significance of the data used.

$$E_3 = E_2 - .012\,\rho I \left(\log \frac{d}{r} - \log \frac{2d - r}{d}\right)$$

E_3 = Potential at radius r over pipe
E_2 = Potential measured at ground surface
ρ = Soil resistivity
d = Depth of pipe burial in feet
r = Radius from center axis of pipe where E_3 is to be determined in feet
I = ma of protective current per lineal foot of pipe

Coatings

The use of a good high resistance coating greatly lessens the importance of the reference electrode location. Since nearly all the IR drop form of cathodic polarization occurs across this resistive coating, the potential observed is comparatively independent of the reference electrode location. Low re-

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XUM

sistivity soils also allow some wider latitude in the location of a reference electrode position to make significant observations.

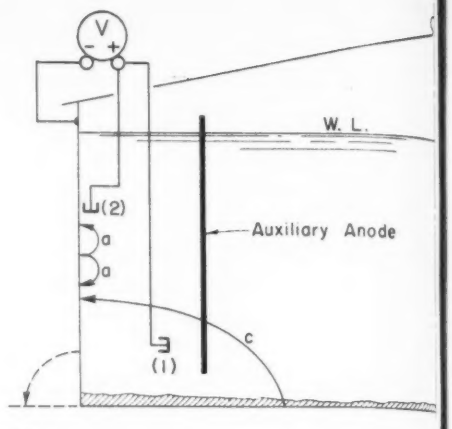
The IR drop form of cathodic polarization through the conductive soil component of the protected corrosion system may only be a small part of the total polarization. In any instance, the raising of the earth potential by the protective anode system or the shielding and/or foreign effects of neighboring structures must also be considered.

Null Methods

Thought must also be given to the "Null Methods" of potential measurement. Since they either exclude all the IR drop form of polarization, or only the (R_{ef}) effect, one of their values in high resistivity soils is to identify a change in the cathode area electrode reaction. It has been observed in some very high resistivity environments that protection can be attained through IR drop potential effects alone with no discernible cathodic reaction change.

The use of earth current measurement methods also have some evident limitations particularly where the attack is of a pitting or localized nature.

FIG. 3. Cathodic protection bare standpipe (protective current from vertically hung anodes).



Ⓥ Potentiometer
(1) Semi remote reference electrode
(2) Near metal surface reference electrode
a. Local cell current
c. Long line galvanic current

Examples

To illustrate the concept just presented we shall use three examples which intentionally exclude outside effects such as shielding and interference from foreign structures. When the latter effects do occur they must be considered by the corrosion engineer.

CASE A: (Fig. 1) A section of bare pipe line, insulated at each end and receiving protective current from a remote anode bed (the pipe line is outside the easily discernible protective anode potential gradient).

CASE B: (Fig. 2) A section of bare pipe line, insulated at each end and receiving protective current from distributed anodes.

CASE: (Fig. 3) An uncoated water standpipe protected from vertically hung anodes.

Case A

The relation of the Cu-$CuSO_4$ reference electrode location and the control of corrosion currents on a bare pipe line, protected from a remote ground bed, is illustrated by Fig. 1.

1. The corrosion effect of long line current "C" is controlled when — .85 v is measured at location "1." The effects of corrosion current "a" and "b" are lessened.

2. The effects of corrosion currents "b" and "c" are controlled when — .85 v is measured at location "2." The effects of corrosion current "a" are lessened.

3. The effects of corrosion currents "a," "b" and "c" are controlled when — .85 v is measured at location "3" near the pipe surface.

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The Authors

Sudrabin

Lehmann

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J. A. Lehmann, project engineer for Electro Rust-Proofing Corporation, has been engaged in corrosion engineering since 1949. He attended Central College, during his training in the Navy V-5 aviation program, after which he attended Columbia University and Brooklyn Polytechnic Institute. Lehmann was previously employed in the corrosion engineering department of Ebasco Services, Incorporated.

Case B

As in Case A, an interpretation of reference electrode location and corrosion current control can be made on a bare pipe line protected by distributed galvanic (magnesium, zinc) anodes (Fig. 2).

In Case A and Case B where the pipe line is not insulated at each end, and shielding effects exist, the reference electrode locations "2" and "3" only should be used and interpreted as described in 2 and 3.

Case C

A water standpipe, Fig. 3 can be used to support some of the views previously discussed. Suspended matter that settles to the floor creates a large oxygen concentration cell between the floor and the side walls directly in contact with aerated water. This cell results in the long line corrosion current flow "c." In spite of some protective effect on the sidewalls by this corrosion current flow, severe localized pitting usually occurs (local cell corrosion current "a").

Potentials measured to a Cu-$CuSO_4$ reference electrode placed near the floor of an unprotected tank in a high-resistivity well-aerated water are in the neighborhood of — .600 v. The average potential on the side wall may be — .300 v. Pits and vertically etched streaks are observed developing randomly over the otherwise cathodic vertical surface.

The potential profile of the vertical wall of the tank measured at 6-in. intervals to a reference electrode lowered at a distance of 12-in. from the wall, will often be outside the electrical boundary of the corroding local cells "a." The discrete anode areas are not identified until the potentials are observed closer to the tank surface.

A potential of — .85 v measured against a reference electrode placed (Location "1") in the bulk of water will indicate control of the harmful effects from corrosion current "c."

In order to control local cell corrosion current "a" a potential of — .85 v must be observed to a reference electrode placed within ½-in. of the sidewall. Much more protective current is required to fully control corrosion current "a" than to control corrosion current "c."

Although plane areas are dealt with in the tank, it is of interest to compare Case A (Fig. 1) with Case C (Fig. 3) when the sidewall of the tank is rotated counter-clockwise 90 degrees.

Conclusions

The preceding illustrations emphasize the importance of spatial factors and the IR drop form of cathodic polarization in the cathodic protection of a bare pipe line. All concentration polarization changes resulting from the ampere-hour protective circuit effects are included in the potential measurements shown.

Since the length of bare pipe most affecting the potential "seen" by the reference electrode is equal to about two times the distance of the reference electrode from the pipe line, frequently spaced potential measurements are indicated for localized pitting control. The experience and competence of the engineer must be called upon to establish the practical and most productive procedure and frequency of measurement to assure localized pitting control on a specific pipe line.

Burial of bare pipe in a high resistivity soil does not give assurance that intense pitting will not occur. Pipe line owners who cannot tolerate either general or incidental pipe wall penetration are well advised to apply a good coating system to a new line, police it with cathodic protection or use appropriate stray current measures where required.

The protective requirements to control local action corrosion current are many times that required to control long line currents. The costs of the cathodic protection required in high resistivity soils to assure control of localized pitting on bare lines often exceed the cost of a combination of coating and a cathodic protection system. Stray current and interference problems induced by the high protection energy requirements for bare pipe lines are a responsibility growing in significance, and must be recognized.

Although past experience in some regions has shown that a particular potential measurement technique has assured adequate protection, exceptions have occurred. The discussion has been directed toward a better understanding of the significance of the techniques used.

The importance of a specific reference electrode location requirement is greatly diminished in low resistivity soils, and where good coatings are used on a pipe line.

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* * *

Tank Vehicle Safety Manual Published

Publication of a new 14-page edition of a safety manual on how to clean tank vehicles used for the transportation of flammable liquids was announced today by the American Petroleum Institute.

The new edition is attractively illustrated, and replaces a tentative manual issued five years ago. It is known as API Accident-Prevention Manual No. 13A. Copies may be obtained through the API for one dollar each.

Purpose of the manual is to provide information on how to clean, prior to repair, any tank vehicle equipment which is used in the transportation of flammable liquids. Attention is called to the measures which should be taken to protect personnel against harmful vapor concentration and to avoid the ignition of flammable vapors which may be present during certain phases of mobile tank-cleaning operations.

Among the subjects covered are preparation of tank units for repair, repair operations, preparation of tank compartments for gas-freeing, methods for gas-freeing tanks, and safety measures for hot work.

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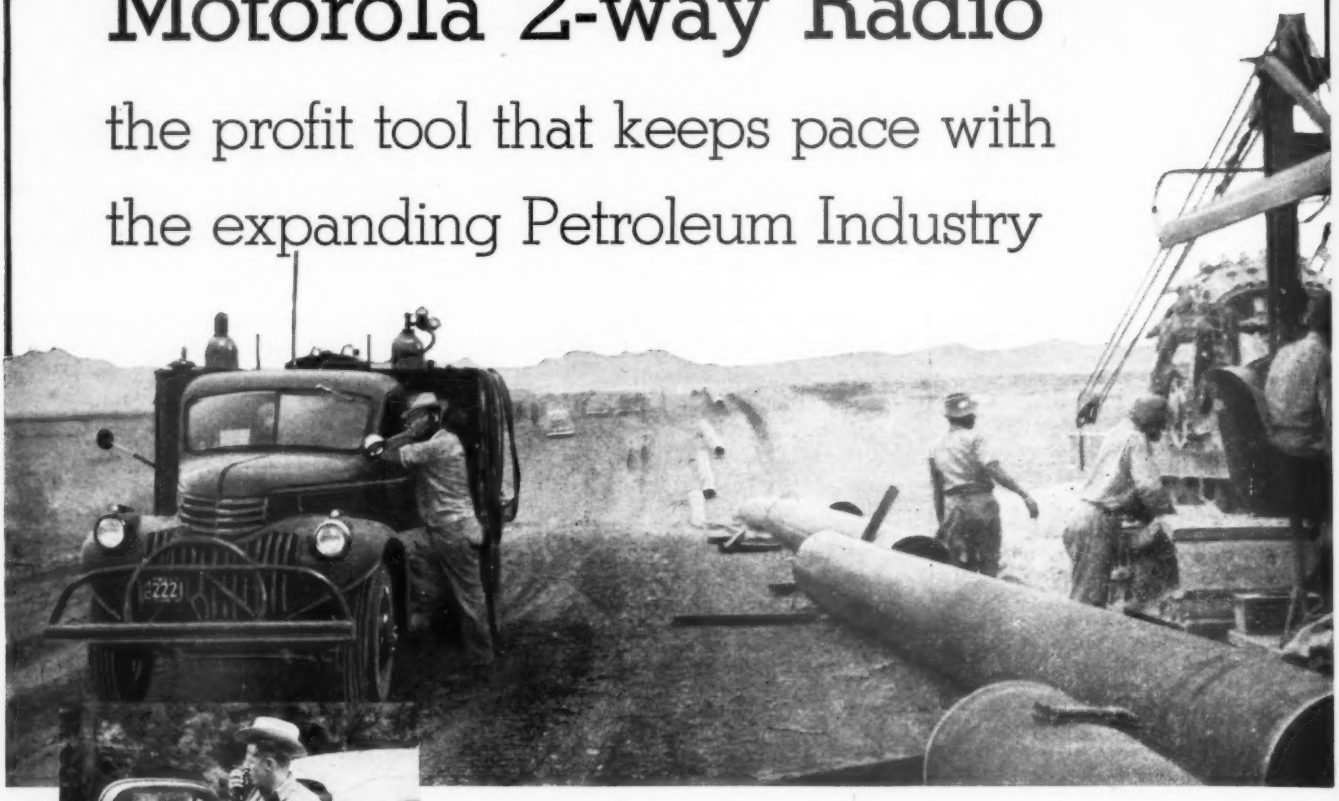

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Calculation of the Flow and Storage of Natural Gas in Pipe—Part III

R. G. Nisle and Fred H. Poettman

TABLE 2.

Page 1 of 5 Pages

Values of $\int_0^{P_r} \left(\frac{P_r}{Z}\right)^2 dP_r$

Multiply Values in Body of Table by 10^4.
For Example: 00198 is Read 1.98.

EDITOR'S NOTE: Text material explaining the use of the following table was published in the January, 1955, issue of Oil . . . Gas . . . Products Pipelining along with Table 3. Table 1 was published in the February issue.

This concludes the 3-part series.

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r									Pseudo reduced Temperature T_r					Pseudo reduced temperature T_r					
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
.05	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
.10	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
.15	000001	000001	000001	000000	000001	000000	000000	000001	000001	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
.20	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002	000002
.25	000005	000005	000005	000005	000005	000005	000005	000005	000005	000005	000004	000004	000004	000004	000004	000004	000004	000004	000004	000004
.30	000010	000010	000009	000009	000009	000008	000008	000009	000009	000008	000008	000008	000008	000008	000008	000008	000008	000008	000008	000008
.35	000016	000016	000016	000015	000015	000014	000014	000015	000014	000014	000014	000013	000013	000013	000013	000013	000013	000013	000013	000013
.40	000025	000025	000024	000023	000023	000022	000022	000022	000022	000022	000021	000021	000021	000020	000020	000020	000020	000020	000020	000020
.45	000038	000036	000035	000033	000034	000032	000032	000032	000032	000031	000030	000030	000030	000030	000029	000029	000029	000029	000029	000029
.50	000054	000051	000050	000047	000047	000045	000045	000045	000045	000043	000042	000041	000041	000041	000041	000040	000040	000040	000040	000040
.55	000074	000070	000068	000064	000064	000061	000061	000061	000060	000058	000057	000056	000055	000055	000055	000054	000053	000053	000053	000053
.60	000100	000094	000091	000085	000085	000081	000080	000080	000079	000077	000075	000073	000073	000072	000072	000071	000070	000070	000070	000070
.65	000132	000124	000118	000111	000109	000105	000103	000103	000102	000099	000096	000094	000093	000092	000091	000091	000089	000089	000089	000089
.70	000172	000160	000151	000142	000139	000133	000130	000130	000129	000125	000121	000118	000117	000116	000115	000114	000112	000111	000111	000111
.75	000220	000204	000191	000178	000174	000167	000163	000162	000160	000155	000150	000147	000145	000144	000142	000140	000139	000137	000137	000137
.80	000280	000256	000238	000221	000215	000205	000201	000199	000196	000190	000184	000179	000177	000175	000173	000171	000169	000167	000167	000167
.85	000352	000318	000294	000271	000263	000250	000244	000241	000237	000230	000222	000216	000213	000211	000208	000205	000203	000200	000200	000200
.90	000441	000392	000358	000329	000317	000303	000294	000290	000284	000275	000266	000259	000255	000251	000248	000245	000242	000238	000238	000238
.95	000548	000479	000433	000397	000380	000362	000350	000345	000337	000326	000315	000306	000301	000297	000293	000289	000285	000281	000281	000280
1.00	000678	000582	000520	000474	000450	000428	000414	000406	000397	000383	000370	000359	000353	000348	000343	000338	000333	000328	000328	000326
1.05	000838	000703	000619	000561	000531	000502	000486	000475	000463	000448	000431	000418	000410	000404	000398	000392	000386	000380	000380	000377
1.10	001038	000846	000733	000660	000622	000587	000567	000552	000537	000520	000500	000483	000474	000466	000460	000451	000445	000437	000437	000433
1.15	001290	001015	000864	000773	000723	000681	000657	000638	000620	000600	000574	000555	000544	000535	000527	000516	000509	000500	000500	000495
1.20	001612	001212	001013	000899	000837	000786	000756	000733	000711	000687	000656	000634	000620	000609	000600	000588	000578	000568	000568	000562
1.25	002035	001445	001183	001040	000965	000903	000866	000837	000810	000782	000747	000720	000704	000691	000681	000667	000655	000642	000642	000635
1.30	002614	001721	001377	001199	001106	001031	000986	000952	000920	000887	000847	000814	000795	000780	000768	000751	000738	000724	000723	000714
1.35	003425	002049	001597	001377	001263	001172	001117	001077	001039	001001	000955	000916	000893	000876	000862	000842	000828	000813	000810	000800
1.40	004589	002438	001847	001575	001437	001329	001262	001214	001169	001126	001072	001027	000999	000980	000964	000940	000925	000908	000904	000893
1.45	006079	002905	002133	001796	001629	001500	001420	001363	001310	001260	001198	001147	001115	001092	001074	001047	001028	001010	001005	000992
1.50	007732	003469	002457	002042	001841	001686	001591	001524	001463	001407	001334	001275	001238	001213	001191	001161	001139	001120	001113	001099
1.55	009541	004137	002824	002316	002075	001890	001777	001699	001628	001563	001480	001413	001371	001342	001317	001282	001258	001237	001228	001211
1.60	011494	004908	003236	002618	002331	002113	001979	001889	001836	001733	001639	001561	001514	001480	001452	001412	001384	001362	001352	001331
1.65	013590	005779	003697	002951	002611	002355	002198	002094	001998	001915	001838	001720	001665	001628	001596	001551	001521	001495	001483	001459
1.70	015807	006740	004209	003318	002917	002615	002433	002315	002204	002111	001989	001889	001827	001785	001749	001699	001665	001636	001621	001595
1.75	018113	007792	004777	003722	003250	002898	002686	002551	002424	002319	002183	002069	002000	001952	001913	001856	001818	001785	001767	001740
1.80	020479	008930	005402	004163	003612	003203	002960	002806	002660	002542	002389	002261	002184	002131	002086	002022	001980	001944	001922	001893
1.85	022896	010146	006087	004643	004003	003533	003253	003078	002912	002779	002607	002465	002379	002319	002270	002198	002151	002111	002086	002055
1.90	025352	011433	006835	005168	004427	003887	003568	003370	003181	003032	002840	002682	002585	002519	002464	002385	002332	002288	002259	002226
1.95	027847	012794	007649	005739	004883	004268	003903	003680	003467	003302	003087	002911	002803	002729	002670	002581	002524	002474	002441	002407
2.00	030380	014222	008530	006359	005374	004677	004262	004010	003771	003587	003347	003153	003032	002952	002887	002787	002726	002670	002633	002595

TABLE 2, Page 2 of 5 Pages

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r									Pseudo reduced Temperature T_r						Pseudo reduced temperature T_r				
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
2.05	032939	015715	009480	007032	005901	005115	004646	004360	004093	003890	003623	003410	003274	003187	003114	003005	002938	002876	002835	002793
2.10	035515	017275	010499	007762	006468	005583	005055	004733	004435	004210	003913	003682	003529	003433	003353	003234	003161	003103	003047	003001
2.15	038108	018898	011587	008546	007076	006082	005490	005129	004798	004548	004221	003967	003798	003693	003604	003474	003394	003319	003270	003219
2.20	040710	020580	012745	009382	007723	006614	005962	005549	005180	004904	004546	004268	004082	003965	003859	003727	003638	003557	003501	003448
2.25	043319	022321	013969	010273	008410	007178	006442	005993	005584	005280	004887	004583	004379	004250	004145	003992	003893	003805	003748	003685
2.30	045935	024122	015255	011215	009140	007780	006961	006462	006010	005677	005243	004913	004692	004550	004435	004268	004163	004066	003996	003935
2.35	048557	025979	016602	012205	009912	008418	007508	006957	006458	006095	005618	005259	005017	004863	004738	004556	004443	004337	004261	004195
2.40	051194	027881	018004	013244	010728	009091	008086	007479	006930	006533	006013	005621	005358	005191	005055	004858	004736	004620	004537	004466
2.45	053845	029829	019458	014330	011588	009798	008695	008027	007427	006992	006425	006001	005714	005534	005386	005173	005041	004915	004825	004749
2.50	056503	031821	020967	015463	012492	010543	009336	008602	007948	007472	006857	006399	006087	005890	005732	005501	005359	005223	005125	005044
2.55	059164	033854	022524	016644	013436	011327	010010	009206	008494	007975	007307	006814	006476	006263	006091	005844	005689	005543	005437	005349
2.60	061832	035926	024118	017869	014420	012147	010716	009839	009065	008503	007778	007246	006882	006652	006463	006201	006032	005876	005762	005667
2.65	064504	038036	025752	019139	015443	013008	011458	010502	009663	009054	008268	007696	007305	007055	006853	006570	006389	006222	006100	005997
2.70	067182	040185	027432	020450	016509	013907	012230	011194	010287	009629	008780	008164	007746	007476	007256	006954	006759	006581	006449	006340
2.75	069865	042373	029149	021807	017616	014844	013038	011916	010938	010227	009315	008654	008202	007911	007676	007355	007145	006953	006811	006694
2.80	072559	044592	030896	023201	018764	015821	013882	012670	011617	010850	009869	009163	008677	008364	008111	007769	007546	007340	007186	007061
2.85	075265	046838	032671	024638	019955	016834	014764	013455	012325	011502	010447	009691	009170	008835	008564	008199	007960	007740	007575	007442
2.90	077975	049109	034476	026112	021185	017887	015680	014273	013061	012179	011049	010239	009682	009322	009033	008643	008390	008155	007979	007837
2.95	080682	051406	036309	027624	022457	018982	016631	015122	013827	012882	011672	010807	010213	009828	009516	009105	008834	008584	008396	008243
3.00	083392	053723	038174	029181	023769	020115	017617	016005	014621	013612	012320	011395	010761	010349	010019	009582	009293	009028	008828	008664
3.05	086113	056053	040068	030772	025122	021286	018638	016921	015447	014368	012994	012007	011329	010891	010537	010075	009767	009487	009272	009099
3.10	088837	058397	041986	032402	026513	022497	019691	017871	016303	015153	013690	012641	011917	011452	011075	010584	010257	009962	009731	009549
3.15	091565	060761	043931	034066	027940	023747	020782	018854	017190	015965	014412	013296	012526	012030	011629	011109	010762	010452	010206	010011
3.20	094302	063142	045907	035766	029402	025032	021910	019872	018106	016805	015157	013973	013153	012628	012201	011653	011284	010957	010696	010488
3.25	097049	065537	047914	037501	030901	026353	023072	020928	019053	017675	015929	014673	013801	013244	012792	012214	011822	011479	011201	010981
3.30	099799	067944	049947	039271	032436	027710	024267	022017	020031	018569	016725	015398	014470	013881	013401	012792	012376	012013	011720	011490
3.35	102552	070363	052006	041077	034008	029109	025502	023139	021040	019494	017545	016147	015162	014537	014028	013387	012948	012565	012254	012012
3.40	105308	072788	054092	042907	035613	030541	026772	024293	022081	020449	018394	016920	015877	015214	014676	014000	013536	013132	012805	012550
3.45	108068	075221	056200	044773	037253	032009	028078	025479	023155	021434	019267	017716	016610	015909	015342	014630	014141	013717	013373	013104
3.50	110830	077665	058328	046671	038927	033516	029420	026699	024260	022447	020170	018536	017367	016628	016027	015278	014764	014319	013955	013672
3.55	113594	080124	060483	048599	040633	035056	030792	027950	025397	023491	021099	019376	018147	017369	016733	015948	015405	014939	014553	014257
3.60	116366	082600	062662	050558	042369	036636	032202	029234	026566	024563	022054	020241	018951	018129	017459	016636	016064	015576	015169	014855
3.65	119141	085087	064866	052543	044138	038249	033644	030550	027765	025667	023040	021132	019779	018913	018204	017343	016741	016231	015799	015471
3.70	121913	087584	067094	054553	045938	039896	035118	031899	028996	026800	024052	022052	020628	019717	018973	018069	017433	016901	016447	016105
3.75	124688	090091	069341	056581	047769	041578	036625	033280	030259	027962	025092	022998	021502	020542	019761	018814	018144	017589	017114	016753
3.80	127471	092608	071609	058642	049631	043301	038166	034695	031555	029153	026159	023971	022396	021390	020569	019574	018873	018296	017798	017419
3.85	130261	095135	073896	060729	051524	045059	039745	036144	032883	030373	027254	024970	023316	022260	021401	020354	019622	019022	018497	018104
3.90	133053	097672	076203	062835	053446	046847	041358	037625	034245	031623	028378	025996	024258	023150	022254	021154	020391	019763	019216	018803
3.95	135847	100222	078533	064967	055396	048665	042999	039138	035638	032903	029530	027049	025226	024066	023127	021974	021175	020524	019953	019521
4.00	138649	102787	080885	067119	057377	050520	044676	040683	037061	034214	030711	028126	026216	025004	024022	022815	021979	021300	020706	020259
4.05	141457	105360	083256	069290	059389	052405	046387	042261	038514	035555	031916	029230	027233	025963	024938	023676	022803	022096	021478	021011
4.10	144268	107942	085645	071488	061429	054321	048127	043871	039998	036923	033151	030358	028273	026948	025875	024558	023643	022912	022270	021784
4.15	147080	110538	088056	073712	063493	056267	049892	045514	041512	038322	034411	031515	029336	027956	026835	025461	024504	023744	023078	022576
4.20	149894	113146	090488	075963	065580	058246	051686	047191	043057	039748	035701	032696	030421	028987	027816	026386	025386	024597	023906	023384
4.25	152710	115763	092938	078235	067696	060249	053516	048898	044633	041206	037017	033901	031531	030040	028819	027328	026285	025466	024751	024212
4.30	155532	118387	095406	080533	069839	062284	055376	050636	046240	042691	038364	035136	032663	031117	029850	028291	027206	026357	025616	025061
4.35	158356	121024	097890	082859	072008	064352	057273	052405	047876	044209	039737	036396	033825	032217	030903	029277	028147	027264	026498	025926
4.40	161176	123673	100391	085205	074205	066445	059202	054206	049541	045755	041136	037682	035011	033340	031980	030285	029107	028193	027401	026808
4.45	163997	126330	102910	087572	076425	068564	061155	056038	051236	047328	042567	038998	036221	034487	033080	031315	030088	029144	028326	027711
4.50	166820	128994	105444	089959	078669	070715	063133	057901	052960	048936	044025	040339	037456	035663	034203	032364	031087	030112	029267	028635
4.55	169645	131671	107995	092367	080939	072893	065143	059796	054713	050572	045510	041707	038716	036859	035350	033436	032108	031102	030231	029577
4.60	172471	134358	110562	094789	083235	075098	067178	061720	056494	052231	047023	043101	040002	038079	036517	034531	033148	032110	031212	030536
4.65	175303	137052	113144	097232	085555	077322	069245	063673	058303	053918	048563	044521	041312	039324	037707	035645	034211	033140	032211	031518
4.70	178145	139753	115742	099696	087897	079573	071338	065658	060141	055635	050131	045968	042649	040594	038923	036783	035202	034189	033233	032521
4.75	180989	142466	118359	102182	090621	081852	073464	067671	062008	057382	051727	047443	044011	041890	040163	037940	036396	035261	034273	033543
4.80	183829	145189	120988	104681	092649	084157	075615	069711	063904	059158	053352	048944	045400	043211	041423	039121	037520	036351	035335	034582
4.85	186671	147922	123624	107201	095058	086482	077793	071780	065826	060958	055005	050473	046810	044557	042708	040321	038662	037461	036416	035645
4.90	189513	150666	126275	109743	097490	088835	079998	073881	067776	062788	056681	052024	048246	045925	044019	041546	039828	038593	037516	036726
4.95	192357	153421	128940	112299	099944	091209	082222	076011	069754	064648	058386	053604	049704	047319	045355	042791	041014	039745	038639	037826
5.00	195202	156185	131616	114877	102419	093603	084474	078165	071759	066533	060115	055205	051189	048734	046712	044061	042225	040917	039787	038949
5.05	198048	158959	134302	117476	104915	096025	086752	080341	073791	068449	061873	056836	052702	050176	048096	045352	043455	042112	040953	040092
5.10	200899	161743	137002	120097	107433	098475	089057	082543	075851	070396	063655	058495	054236	051645	049500	046662	044710	043328	042139	041258
5.15	203754	164532	139715	122732	109972	100946	091383	084772	077936	072368	065467	060177	055799	053135	050931	047999	045985	044563	043349	042444
5.20	206611	167327	142443	125382	112533	103439	093736	087026	080045	074365	067309	061882	057384	054653	052384	049356	047280	045823	044579	043654
5.25	209469	170132	145185	128047	115114	105945	096116	089307	082183	076388	069176	063616	058907	056194	053858	050739	048601	047103	045829	044884

XUM

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r									Pseudo reduced Temperature T_r						Pseudo reduced temperature T_r				
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
5.30	212327	172946	147940	130733	117714	108473	098524	091614	084348	078436	071067	065381	060638	057756	055360	052144	049943	048403	047104	046139
5.35	215186	175766	150708	133434	120330	111021	100953	093946	086537	080509	072983	067169	062303	059346	056883	053570	051305	049729	048400	047415
5.40	218051	178590	153490	136150	122967	113592	103403	096301	088752	082609	074930	068981	063991	060960	058429	055022	052689	051076	049716	048710
5.45	220916	181424	156285	138888	125624	116184	105881	098679	090991	084734	076902	070817	065708	062601	060002	056496	054098	052444	051052	050026
5.50	223778	184266	159092	141641	128298	118798	108381	101079	093255	086886	078893	072683	067448	064266	061599	057992	055530	053833	052415	051367
5.55	226641	187117	161912	144409	130989	121433	110901	103502	095543	089064	080909	074575	069218	065954	063217	059516	056982	055248	053798	052730
5.60	229509	189977	164741	147184	133696	124083	113443	105947	097856	091268	082957	076490	071012	067671	064865	061062	058456	056684	055202	054113
5.65	232381	192845	167579	149974	136419	126747	116006	108415	100193	093500	085030	078437	072830	069411	066535	062630	059952	058142	056628	055523
5.70	235257	195722	170429	152779	139159	129426	118591	110905	102555	095751	087130	080409	074673	071175	068229	064220	061476	059622	058081	056954
5.75	238139	198607	173291	155599	141915	132120	121190	113417	104942	098029	089255	082400	076539	072963	069946	065833	063022	061129	059555	058407
5.80	241024	201500	176166	158434	144686	134836	123811	115951	107353	100334	091401	084422	078430	074775	071686	067475	064590	062658	061051	059886
5.85	243915	204398	179048	161284	147473	137574	126454	118504	109788	102667	093572	086470	080352	076611	073450	069140	066180	064209	062569	061388
5.90	246809	207300	181932	164142	150276	140327	129111	121076	112247	105020	095770	088544	082299	078472	075239	070827	067799	065783	064115	062911
5.95	249708	210210	184820	167014	153091	143095	131790	123669	114731	107400	097994	090644	084271	080357	077051	072538	069441	067379	065683	064457
6.00	252608	213128	187719	169895	155917	145877	134491	126284	117239	109891	100239	092763	086268	082267	078887	074279	071105	068998	067273	066025
6.05	255507	216053	190630	172783	158759	148675	137214	128921	119771	112230	102510	094908	088291	084201	080747	076043	072793	070639	068886	067616
6.10	258411	218986	193552	175678	161620	151487	139952	131579	122324	114687	104809	097079	090339	086160	082632	077825	074504	072304	070522	069234
6.15	261323	221927	196486	178589	164499	154315	142713	134259	124898	117165	107134	099277	092412	088151	084542	079631	076239	073992	072187	070876
6.20	264242	224875	199427	181508	167393	157157	145488	136960	127496	119672	109480	101501	094505	090167	086476	081467	077997	075703	073875	072541
6.25	267169	227830	202375	184442	170301	160023	148285	139679	130117	122199	111854	103746	096624	092209	088436	083328	079779	077437	075586	074229
6.30	270102	230793	205334	187383	173224	162903	151098	142416	132763	124748	114248	106017	098770	094270	090420	085213	081585	079196	077321	075940
6.35	273037	233760	208304	190332	176159	165799	153925	145174	135432	127319	116670	108323	100941	096356	092430	087122	083415	080984	079079	077680
6.40	275972	236730	211281	193297	179104	168709	156760	147952	138122	129911	119120	110648	103139	098469	094465	089057	085270	082796	080861	079444
6.45	278910	239707	214265	196269	182063	171628	159610	150748	140832	132524	121591	112994	105363	100607	096526	091016	087148	084632	082667	081232
6.50	281848	242691	217259	199257	185036	174562	162483	153562	143562	135167	124084	115368	107608	102772	098613	093001	089052	086492	084497	083044
6.55	284790	245681	220265	202252	188024	177511	165371	156396	146313	137832	126604	117762	109879	104957	100719	095011	090980	088377	086357	084881
6.60	287742	248679	223276	205255	191025	180475	168275	159254	149087	140518	129146	120184	112178	107168	102851	097046	092933	090287	088236	086741
6.65	290701	251684	226295	208266	194036	183463	171201	162132	151882	143226	131709	122634	114503	109406	105009	099107	094911	092221	090140	088626
6.70	293663	254295	229324	211285	197058	186466	174142	165024	154693	145964	134301	125105	116856	111664	107193	101193	096915	094181	092068	090536
6.75	296632	257713	232363	214311	200093	189485	177099	167929	157524	148725	136915	127605	119230	113949	109405	103299	098944	096159	094021	092470
6.80	299608	260737	235408	217345	203141	192519	180071	170851	160375	151507	139557	130125	121631	116261	111642	105431	100998	098169	095999	094429
6.85	302591	263767	238459	220387	206200	195561	183059	173794	163246	154305	142222	132667	124053	118600	113907	107583	103078	100204	098003	096414
6.90	305580	266803	241520	223445	209264	198619	186062	176756	166137	157125	144908	135237	126503	120967	116192	109761	105184	102265	100032	098424
6.95	308575	269846	244591	226518	212338	201692	189088	179738	169047	159967	147617	137829	128974	123354	118504	111965	107316	104351	102086	100459
7.00	311577	272895	247667	229599	215426	204773	192130	182740	171977	162833	150355	140443	131473	125769	120843	114197	109475	106464	104166	102520
7.05	314581	275951	250750	232696	218526	207870	195188	185758	174926	165721	153108	143086	133994	128212	123210	116454	111659	108602	106272	104606
7.10	317589	279012	253839	235801	221638	210982	198269	188792	177895	168632	155883	145750	136536	130676	125597	118739	113864	110761	108404	106719
7.15	320600	282079	256933	238913	224764	214103	201366	191843	180882	171558	158680	148437	139106	133168	128012	121051	116095	112945	110562	108857
7.20	323610	285152	260037	242034	227902	217239	204478	194909	183889	174507	161500	151152	141698	135682	130448	123384	118353	115156	112747	111022
7.25	326623	288231	263150	245162	231052	220399	207607	197995	186916	177479	164343	153890	144312	138224	132912	125744	120638	117394	114951	113207
7.30	329646	291316	266272	248299	234216	223575	210751	201100	189961	180467	167208	156651	146955	140787	135405	128131	122950	119659	117183	115418
7.35	332678	294407	269403	251451	237391	226767	213911	204224	193026	183470	170096	159433	149626	143372	137918	130539	125289	121951	119441	117656
7.40	335715	297503	272542	254619	240578	229975	217087	207368	196109	186488	173007	162238	152320	145985	140460	132975	127649	124263	121725	119920
7.45	338756	300604	275690	257795	243778	233191	220279	210526	199211	189530	175941	165066	155043	148621	143023	135439	130036	126602	124037	122212
7.50	341798	303712	278847	260979	246990	236423	223487	213701	202331	192596	178898	167916	157789	151278	145615	137924	132451	128969	126377	124531
7.55	344847	306825	282013	264171	250213	239664	226711	216890	205471	195677	181878	170789	160556	153964	148229	140438	134894	131356	128743	126877
7.60	347902	309946	285188	267371	253449	242920	229943	220092	208628	198782	184873	173684	163346	156673	150864	142980	137358	133771	131131	129244
7.65	350931	313076	288371	270579	256692	246184	233192	223309	211804	201910	187899	176603	166159	159411	153529	145543	139850	136214	133546	131638
7.70	353965	316212	291562	273795	259944	249465	236456	226544	214999	205054	190949	179544	168994	162171	156215	148128	142364	138685	135989	134060
7.75	357033	319353	294762	277019	263208	252753	239728	229797	218212	208214	194015	182509	171859	164961	158931	150741	144906	141184	138460	136510
7.80	360103	322498	297970	280259	266486	256050	243017	233069	221443	211398	197104	185504	174747	167774	161669	153384	147476	143705	140959	138988
7.85	363178	325650	301186	283507	269779	259363	246322	236355	224689	214598	200216	188515	177658	170609	164429	156048	150075	146254	143487	141495
7.90	366263	328809	304407	286764	273087	262684	249643	239652	227949	217822	203345	191549	180592	173466	167219	158742	152703	148842	146036	144029
7.95	369354	331973	307632	290028	276410	266022	252980	242961	231228	221063	206497	194599	183549	176347	170032	161458	155353	151424	148613	146585
8.00	372446	335141	310863	293300	279743	269367	256326	246285	234525	224319	209673	197672	186529	179250	172867	164196	158032	154052	151213	149170
8.05	375544	338313	314098	296581	283088	272721	259688	249623	237835	227583	212873	200769	189539	182176	175732	166964	160734	156709	153841	151777
8.10	378649	341489	317338	299869	286447	276083	263066	252972	241160	230864	216089	203890	192574	185133	178628	169754	163464	159395	156491	154412
8.15	381763	344671	320583	303166	289820	279453	266461	256335	244500	234169	219034	207034	195631	188113	181546	172574	166217	162104	159170	157077
8.20	384882	347861	323836	306471	293205	282832	269864	259716	247854	237498	222577	210202	198705	191116	184488	175416	168992	164842	161878	159763
8.25	388004	351058	327097	309784	296599	286226	273284	263114	251223	240843	225850	213394	201801	194142	187452	178289	171797	167699	164609	162479
8.30	391127	354260	330365	313105	300006	289630	276712	266530	254605	244205	229146	216610	204922	197192	190447	181185	174625	170399	167369	165217
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8.40	397390	360678	336924	319780	306840	296485	283609	273402	261422	250979	235789	223098	211234	203362	196508	187052	180370	176062	172972	170782
8.45	400533	363893	340214	323134	310271	299930	287070	276853	264853	254390	239142	226379	214426	206491	199574	190025	183289	178927	175807	173602
8.50	403684	367116	343511	326496	313713	303391	290540	280318	268298	257818	242521	229676	217642	209635	202663	193028	186230	181823	178672	176452

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r																					
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
8.55	406843	370346	346816	329866	317160	306861	294018	283797	271760	261263	245916	232997	220882	212803	205783	196054	189195	184749	181568	179335
8.60	410006	373584	350128	333244	320616	310338	297512	285238	275238	264724	249327	236334	224139	215995	208927	199104	192182	187698	184486	182228
8.65	413174	376829	353446	336631	324078	313824	301015	290794	278730	268201	252755	239696	227419	219219	212095	202185	195201	190670	187435	185154
8.70	416347	380082	356775	340084	327546	317319	304526	294336	282236	271696	256199	243083	230724	222459	215267	205290	198243	193674	190407	188111
8.75	419524	383342	360111	343446	331022	320830	308046	297845	285758	275207	259660	246486	234035	225723	218495	208418	201316	196700	193411	191091
8.80	422708	386608	363458	346865	334503	324350	311582	301391	289297	278727	263163	249914	237399	229012	221735	211570	204413	199758	196437	194094
8.85	425897	389879	366811	350293	337995	327878	315127	304949	292852	282272	266675	253358	240769	232325	225000	214746	207542	202839	199495	197128
8.90	429090	393154	370172	353729	341497	331423	318689	308521	296423	285833	270203	256819	244164	235663	228288	217946	210694	205943	202576	200186
8.95	432290	396439	373539	357174	345008	334976	322259	312105	300008	289412	273747	260306	247584	239025	231601	221179	213870	209080	205680	203267
9.00	435495	399734	376913	360627	348528	338646	325703	315703	303605	293007	277309	263817	251020	242411	234939	224435	217070	212240	208817	206380
9.05	438703	403036	380294	364088	352059	342125	329450	319313	307216	296611	280896	267345	254481	245814	238293	227715	220294	215432	211977	209516
9.10	441916	406345	383681	367557	355599	345712	333062	322937	310840	300232	284500	270808	257967	249242	241671	231020	223542	218636	215161	212684
9.15	445133	409660	387078	371035	359148	349307	336692	326577	314479	303870	288121	274468	261470	252695	245074	234349	226814	221885	218377	215884
9.20	448035	412982	390484	374521	362706	352911	340330	330232	318138	307526	291751	278055	264990	256164	248502	237695	230111	225160	221167	219108
9.25	451580	416312	393897	378016	366273	356532	343976	333900	321813	311198	295397	281668	268534	259659	251955	241065	233432	228457	224881	222356
9.30	454810	419647	397317	381518	369850	360162	347632	337581	325499	314887	299061	285297	272104	263179	255433	244460	236778	231778	228178	225629
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9.40	461284	426339	404175	388541	377022	367446	354985	344975	332911	322318	306457	292625	279304	270285	262464	251324	243543	238494	234845	232255
9.45	464530	429694	407613	392069	380620	371101	358674	348686	336635	326050	310181	296314	282934	273872	266017	254794	246963	241889	238215	235609
9.50	467781	433053	411058	395605	384227	374765	362372	352409	340372	329800	313922	300021	286589	277485	269587	258288	250407	245317	241610	238995
9.55	471039	436415	414508	399142	387842	378437	366079	356144	344124	333558	317680	303744	290269	281114	273182	261808	253877	248770	245030	242407
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9.65	477563	443158	421431	406240	395097	385808	373535	363650	351681	341145	325249	311261	297683	288441	280450	268906	260891	255750	251960	249304
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9.95	497233	463526	442372	427720	417043	408151	396147	386452	374680	364236	348341	334230	320434	310949	302768	290760	282566	277299	273390	270666
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10.05	503831	470355	449408	434953	424425	415676	403768	394145	382454	372060	356164	342027	328178	318623	310398	298234	289988	284686	280752	278002
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10.60	540412	508320	488552	475228	465650	457716	446405	437311	426113	416001	400384	386184	372219	362432	353913	341086	332611	327213	323155	320266
10.65	543759	511804	492143	478935	469457	461597	450338	441303	430154	420078	404497	390307	376341	366537	357999	345118	336634	331236	327179	324371
10.70	547108	515295	495740	482642	473261	465478	454281	445306	434211	424173	408629	394456	380482	370659	362103	349177	340684	335286	331229	328303
10.75	550461	518790	499344	486357	477071	469367	458242	449321	438278	428277	412769	398624	384641	374799	366226	353203	344761	339363	335297	332362
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10.90	560538	529294	510194	497537	488535	481089	470177	461443	450552	440653	425291	411219	397236	387330	378711	365657	357155	351739	347664	344702
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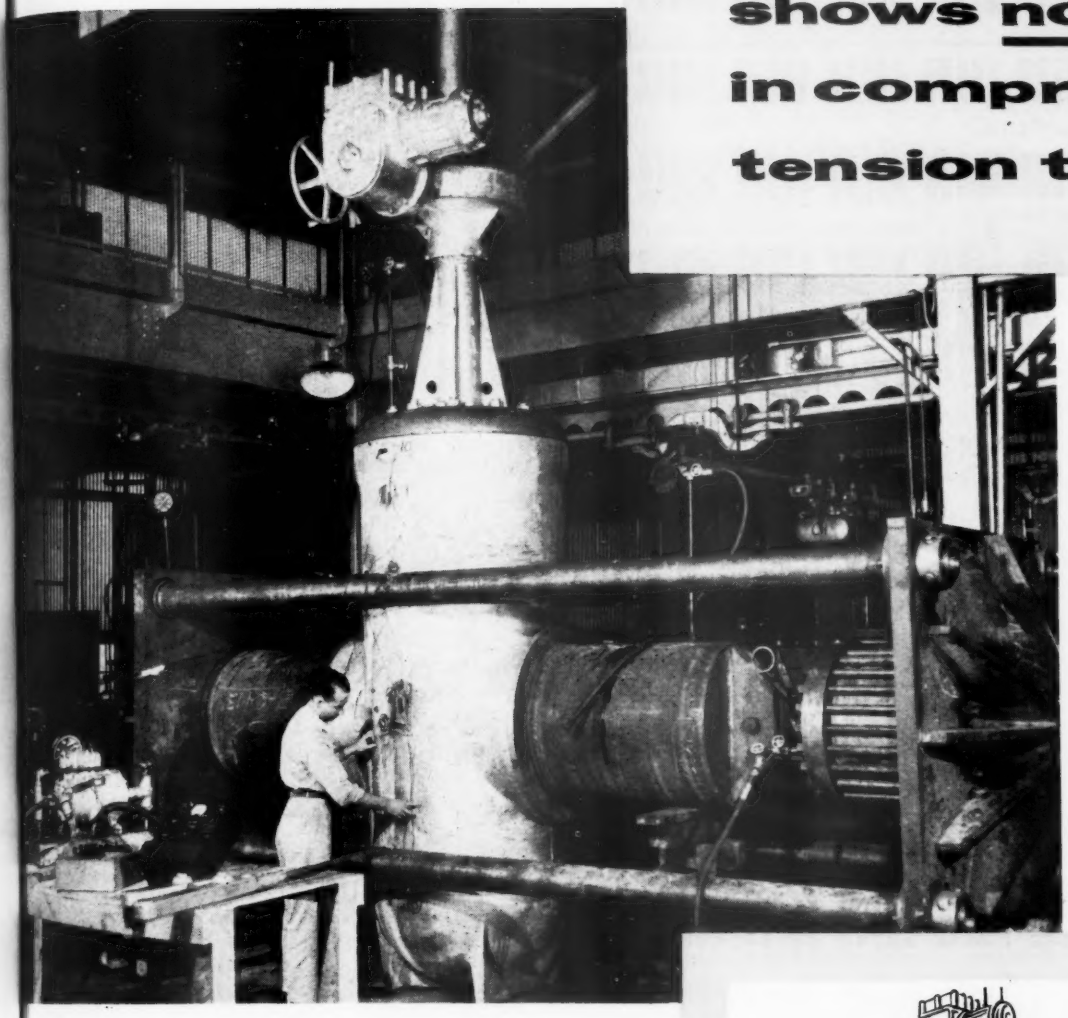
11.00	567273	536322	517461	505019	496216	488939	478178	469576	458793	448971	433700	419692	405709	395776	387138	374038	365537	360111	356036	353065
11.05	570649	539843	521103	508769	500067	492873	482192	473661	462932	453148	437932	423943	409978	400027	391379	378270	369769	364334	360259	357288
11.10	574027	543369	524750	512519	503926	496816	486215	477760	467085	457334	442182	428212	414265	404295	395648	382521	374019	368585	364509	361538
11.15	577409	546901	528406	516277	507788	500767	490247	481869	471249	461538	446451	432499	418580	408592	399936	386799	378297	372863	368787	365816
11.20	580797	550437	532068	520044	511655	504728	494288	485987	475422	465722	450729	436805	422905	412907	404242	391105	382603	377169	373093	370122
11.25	584189	553979	535735	523820	515528	508697	498338	490117	479609	469984	455017	441130	427248	417241	408575	395429	386925	381493	377418	374447
11.30	587586	557525	539406	527596	519410	512676	502397	494256	483809	474225	459313	445473	431610	421593	412928	399782	391260	385846	381770	378799
11.35	590989	561077	543083	531381	523299	516663	506465	498406	488019	478485	463629	449684	435990	425965	417299	404133	395651	390217	386151	383180
11.40	594395	564633	546763	535174	527195	520659	510542	502565	492239	482754	467953	454206	440389	430364	421698	408552	400051	394616	390559	387588
11.45	597804	568195	550448	538967	531098	524673	514628	506734	496472	487032	472296	458505	444708	434782	426116	412970	404469	399043	394987	392025
11.50	601218	571758	554139	542769	535007	528687	518723	510912	500718	491319	476649	463004	449225	439219	430553	417407	408905	403490	399442	396490
11.55	604637	575324	557833	546579	538923	532710	522928	515104	504974	495616	481020	467422	453672	443674	435009	421863	413370	407964	403926	400974
11.60	608058	578894	561532	550390	542846	536742	526941	519308	509239	499922	485400	471859	458137	448149	439483	426347	417855	412458	408429	405487
11.65	611482	582470	565235	554210	546776	540783	531063	523523	513517	504246	489790	476305	462621	452642	443977	430850	422367	416980	412961	410028
11.70	614911	586050	568944	558038	550716	544824	535194	527747	517808	508580	494199	480770	467114	457155	448499	435381	426908	421530	417521	414597
11.75	618346	589634	572656	561875	554666	548874	539344	531980	522112	512923	498617	485254	471627	461686	453030	439932	431478	426109	422100	419189

W-K-M Valve shows no leak in compression-tension tests



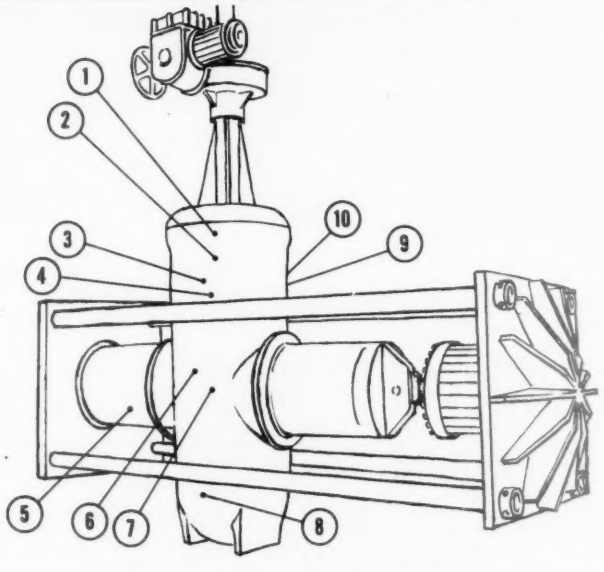
A special test was made in the W-K-M plant to determine what effect external compression and tension loads would have on seal-off and operation of a W-K-M Valve.

This test was conducted using a 30" ASA 400 p.s.i. weld-end gate valve operated by an electric motor. Ten strain gages were placed in the valve at locations shown on the diagram at right.

Using a hydraulic cylinder, an external differential tension load of 675 tons was applied to the valve while maintaining maximum working pressure against the gate.

During the tests the recorded strain-gage readings indicated no fibre stresses in excess of code allowables, indicating no appreciable body distortion. The valve did not leak and operated freely under all conditions.

W-K-M Pipeline Valves have been tested and proved in the laboratory and out on the line for more than thirty years. They offer the world's finest valve performance. Ask a W-K-M sales engineer to demonstrate a scale model valve.



The above sketch shows the placement of the strain gages used in the test.

W-K-M Valves

W-K-M Manufacturing Company, Inc.
A subsidiary of A.C.F. Industries Incorporated

P. O. Box 2117, Houston 1, Texas
Los Angeles, California
Export Office: 45 Rockefeller Plaza, New York, N. Y.

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r																							
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
11.80	621783	593224	576373	565720	558622	552924	548503	536224	526429	517295	503053	489748	476158	466227	457581	444511	436067	430708	426708	423804
11.85	625222	596818	580094	569566	562585	556983	547682	540476	530755	521656	507500	494260	480709	470788	462160	449110	440684	435335	431345	428450
11.90	628667	600417	583820	573420	566555	560551	551829	544738	535091	526037	511955	498782	485279	475376	466759	453727	445321	439991	436011	433126
11.95	632116	604020	587580	577275	570831	565128	556006	549137	539440	530427	516430	503314	489868	479975	471376	458574	449607	444067	440706	437821
12.00	635568	607625	591284	581138	574514	569214	560192	553291	543801	534826	520914	507864	494466	484592	476013	463039	454672	449371	445420	442545
12.05	639023	611232	595022	585010	578503	573300	564388	557584	548171	539234	525408	512434	499084	489229	480669	467725	459386	454105	450163	447298
12.10	642481	614844	598764	588891	582499	577396	568592	561890	552550	543662	529920	517013	503720	493895	485345	472439	464129	458868	454926	452070
12.15	645945	618460	602510	592771	586502	581500	572806	566205	556939	548009	534452	521612	506367	498580	490049	477172	468902	463650	459718	456872
12.20	649411	622081	606261	596652	590510	585613	577029	570528	561337	552545	538993	526229	513033	503275	494773	481935	473694	468462	464540	461704
12.25	652880	625706	610016	600542	594525	589735	581261	574861	565743	557010	543643	530857	517718	507989	499516	486718	478506	473283	469391	466555
12.30	656353	629335	613774	604440	598547	593858	585502	579203	570162	561485	548103	535503	522413	512723	504279	491529	483347	478144	474262	471436
12.35	659831	632969	617537	608339	602574	597989	589752	583555	574593	565969	552673	540169	527127	517476	509062	496361	488208	483025	479152	476336
12.40	663311	636607	621304	612246	606608	602130	594012	587915	579033	570462	557262	544844	531860	522249	513804	501222	493099	487936	484073	481266
12.45	666794	640250	625075	616153	610648	606270	598281	592287	583482	574965	561860	549529	536604	527041	518685	506103	498009	492876	489023	486216
12.50	670281	643894	628850	620069	614694	610420	602559	596671	587940	579487	566478	554234	541367	531853	523527	511003	502950	497846	494003	491196
12.55	673773	647539	632628	623994	618744	614578	606846	601064	592410	584019	571105	558048	546149	536684	528388	515923	507910	502836	499003	496206
12.60	677268	651189	636411	627919	622797	618746	611143	605466	596882	588560	575742	563082	550941	541535	533268	520864	512890	507846	504033	501247
12.65	680765	654844	640197	631853	626853	622923	615449	609876	601382	593110	580388	568425	555753	546406	538169	525834	517900	512886	509083	506307
12.70	684267	658502	643988	635787	630912	627100	619785	614295	605884	597670	585054	573188	560575	551297	543089	530824	522940	517956	514163	511397
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12.80	691284	665829	651580	643681	639049	635482	628394	623159	614922	606819	594415	582753	570277	561117	552989	540874	533090	528167	524405	521649
12.85	694799	669496	655382	647633	643126	639677	632728	627605	619456	611408	599110	587555	576058	566058	557969	545834	538201	533308	529566	526820
12.90	698319	673167	659190	651594	647210	643881	637071	632061	624063	616016	603814	592376	580058	571018	562969	551024	543332	538470	534748	532022
12.95	701843	676842	663005	655554	651299	648095	641424	636530	628557	620634	608538	597218	584969	575988	567979	556135	548493	543661	539960	537245
13.00	705369	680521	666824	659523	655394	652318	645786	641004	633120	625261	613272	602069	589899	580978	573020	561266	553685	548884	545203	542487
13.05	708897	684204	670646	663493	659494	656541	650157	645482	637692	629898	618015	606930	594849	585988	578080	566417	558897	554137	550466	547761
13.10	712429	687891	674471	667471	663601	660773	654528	649973	642275	634544	622778	611811	599809	591018	583160	571588	564130	559411	555760	553066
13.15	715966	691582	678300	671449	667714	665014	658908	654475	646870	639200	627550	616711	604789	596068	588261	576780	569393	564715	561075	558401
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13.65	751538	728665	716833	711555	709153	707777	703136	699960	693379	686382	675895	666452	655412	647489	640333	630013	623351	619162	615689	613172
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13.75	758698	736116	724584	719646	717506	716398	712075	709169	702790	695947	685716	676573	665714	657975	650983	640933	634449	630356	626925	624440
13.80	762281	739847	728465	723696	721691	720722	716559	713781	707510	700739	690646	681053	670896	663249	656339	646435	640036	635995	632586	630122
13.85	765867	743583	732349	727746	725879	725047	721053	718405	712242	705541	695576	686743	676088	668543	661716	651958	645654	641655	638268	635825
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Pipe Line Projects

Pipe Line Sessions Slated At NACE Chicago Meeting

Of interest to pipe line people concerned with corrosion will be three important sessions at the 1955 conference and exhibition of the 11th annual National Association of Corrosion Engineers meeting in Chicago, March 7-11.

The schedule includes:

Wednesday, March 9

Pipe Line General Symposium
J. N. Hunter, Jr., Service Pipe Line Company, Tulsa, chairman.

Internal Plastic Coating of Pipe Lines in Place, by J. C. Watts, Jr., Humble Pipe Line Company, Midland, Texas.

A Discussion of the Committee T-2D Report "Proposed Standard Method for Measuring Electrical Conductance of Coating on Buried Pipe Lines" by L. F. Heverly, Buckeye Pipe Lines Company, Lima, Ohio.

Thursday, March 10

Pipe Line Problem Clinic
R. L. Bullock, Interstate Oil Pipe Line Company, Shreveport, and Lyle R. Sheppard, Shell Pipe Line Corporation, Houston, are chairman and vice chairman.

Cathodic Protection Clinic, Charles L. Woody, United Gas Corporation, Houston, discussion leader.

Internal Corrosion Clinic—Pipe Lines and Storage Tanks, Ivy M. Parker, Plantation Pipe Line Company, Atlanta, discussion leader.

Protective Coatings Clinic—Pipe Lines, L. A. Hugo, Phillips Petroleum Company, Bartlesville, Oklahoma, discussion leader.

Friday, March 11

Pipe Line and Underground Corrosion Roundtable, Jack P. Barrett, Stanolind Oil & Gas Company, Tulsa, and Loyd B. Nelson, Shell Pipe Line Corporation, Houston, are charman and vice chairman.

Trans-Canada Signs First Distributor Contract

The first—and one of the most important—Canadian natural gas contracts required by Trans-Canada Pipe Lines, Ltd., has been signed with Union Gas Company of Canada, Ltd.

The contract calls for 20-year deliveries of Alberta gas to Union's system in southwestern Ontario. Over this period, Union will purchase in excess of 300 billion cu ft of natural gas from Trans-Canada and deliveries will start soon after the Trans-Canada line reaches Toronto.

Construction on the 2250-mile Alberta-Montreal pipe line is expected to start this spring and Alberta natural gas is scheduled to arrive in Toronto in November, 1956.

Union plans to expand its present system, particularly in the Hamilton area where there is a large industrial, commercial and domestic market for natural gas. Union now imports American gas from the Panhandle line at Detroit to augment local supplies. The company is seeking approval of the Federal Power Commission to increase these imports for market development until it can obtain Alberta gas from Trans-Canada.

Additional supply of gas sought from the U.S. would permit extension of natural gas service to the Hamilton area, including Dundas, Burlington and Oakville, to the cities of Stratford, Kitchener, Waterloo, Guelph and to other municipalities. A new large diameter pipe line, costing in excess of $14,000,000, will be constructed from the Dawn underground storage field, near Sarnia, to a point just north of Hamilton. When Alberta gas arrives, a connecting line will be built from Hamilton to Sheridan, the area terminus of the Trans-Canada line.

TGT Asks Authority to Construct 370-Mile Line

Tennessee Gas Transmission Company has asked the Federal Power Commission for authority to construct a 370-mile, 30-in. natural gas pipe line from Agua Dulce in South Texas along the shore line of the Gulf Coast of Texas and Louisiana to Kinder, Louisiana.

The $35,400,000 pipe line will be capable of transmitting 270,000,000 cu ft of gas per day from the company's compressor station on its main system near Agua Dulce to its compressor station near Kinder. The Kinder station is at the south end of a 576-mile, 30-in. pipe line built in 1954 by the company northeast across Louisiana, Mississippi, and Tennessee, connecting with its main multiple-line system near Portland, Tennessee, north of Nashville.

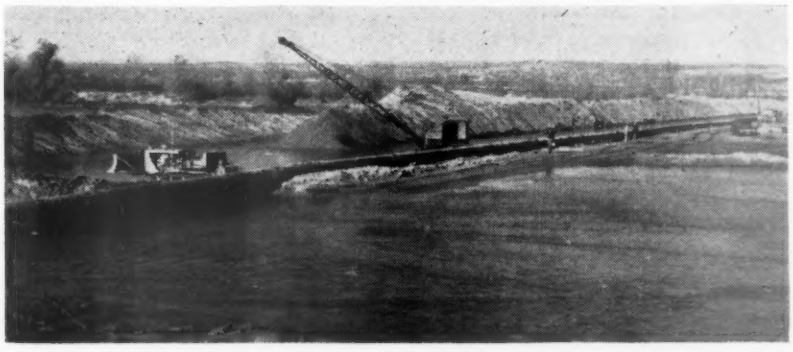
Financing Approved by FPC For Pacific Northwest Line

A plan for financing the $163,000,000 Pacific Northwest Pipe Line Corporation's construction of its 1500-mile system from the San Juan Basin to northwestern states has been approved by the Federal Power Commission.

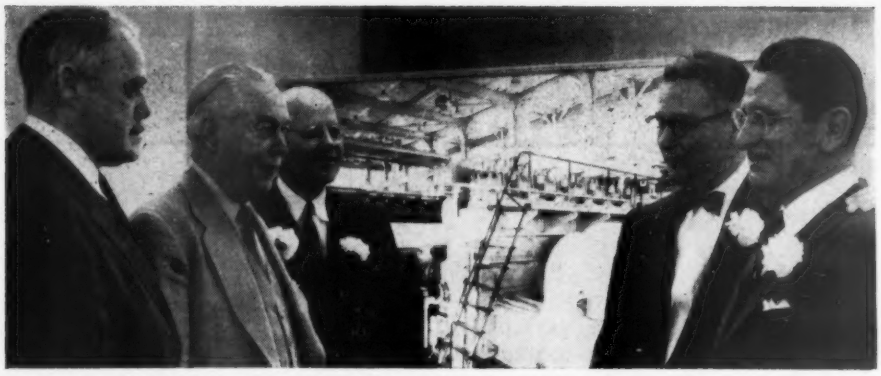
Ray C. Fish of Houston, Pacific's board chairman, said that the financing is expected to be completed in March. Construction of the line, he said, will start "immediately thereafter."

The financing includes only that portion of the pipeline that has been approved by the commission.

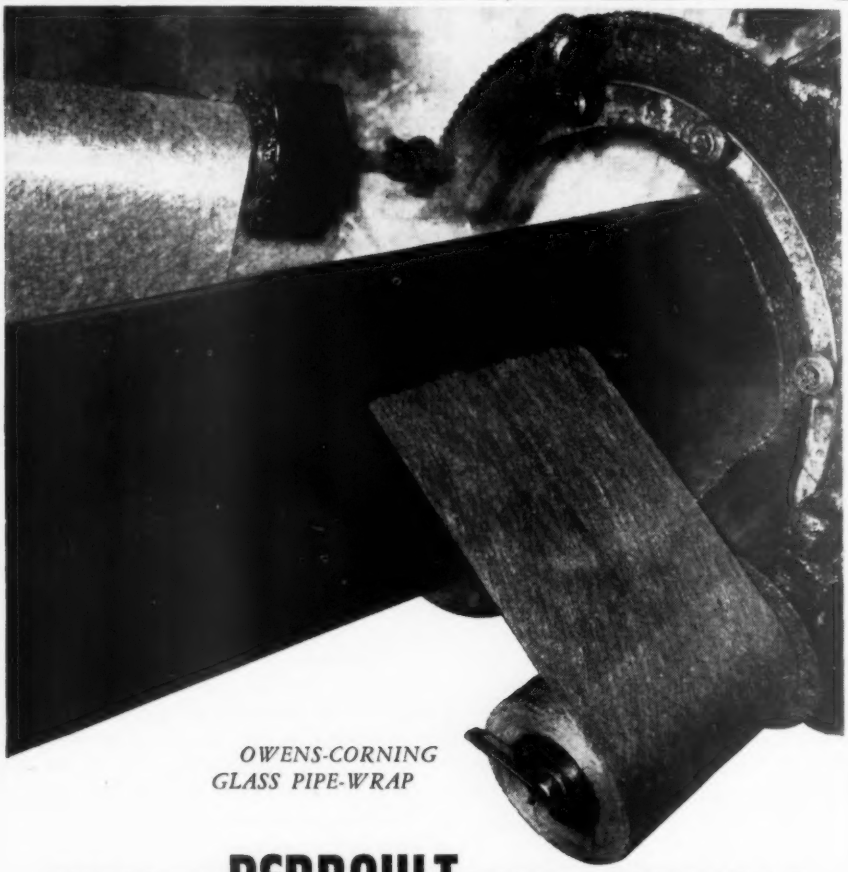
IDEA!



Crossing the South Platte river with its new Wyoming-Nebraska crude line, Service Pipe Line employed a unique method. A long crossing was needed here to cross both the river and an adjacent irrigation ditch. After the trench was cut, the jacketed pipe was laid out alongside the trench and skidded into the cut, using sideboom tractors. River pipe used was coated with coal tar and glass wrap, and encased in a concrete jacket for protection and weight.



Among the 400 Oklahoma business and industrial leaders at the opening in Tulsa recently of new and expanded facilities of Clark Brothers Co. were J. N. MacKendrick, president, Clark Brothers; J. B. O'Connor, executive vice president of Dresser Industries; H. N. Mallon, president of Dresser; William H. Barnes, Clark's Tulsa district manager, and E. L. Andrew's Dresser's director of facilities.



OWENS-CORNING GLASS PIPE-WRAP

POSITIVE PERRAULT PIPE PROTECTION

Owens-Corning Fiberglas Coromat pipeline wrap is available through Perrault Equipment Co. in average thicknesses of .020 and .025 in.; in widths from two to 18 in.; and roll lengths of 400, 800, and 1200 ft. High strength and porosity combined with inert reaction to weather, chemicals and electricity make this the best pipeline coating reinforcement. For the best service, get it from Perrault Equipment Co.

ALSO: Asbestos Pipeline Felt • Pipeline Kraft Wrap • Rock Shield

AND FOR DEPENDABLE APPLICATION: Perrault Line Travelling, Over-the-ditch, Coating and Wrapping Machines and Yard or Railhead Stationary Coating and Wrapping Machines.

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meetings . . .

Tulsa Corrosion Short Course Successful

The 6th annual Tulsa short course for pipeliners was held February 16-18 at the Mayo Hotel, Tulsa, Oklahoma. The popular 3-day course, sponsored by the Tulsa section of National Association of Corrosion Engineers, included discussions, lectures and actual field demonstrations on corrosion fundamentals, detection and prevention.

Topics covered by authorities in corrosion were: How to Detect Corrosion on Pipe Lines; Methods for Stopping Corrosion—With Expendable Anodes—With Rectifiers; Instruments for Corrosion Control; How a Pipeliner May Help a Corrosion Engineer; plus general roundtable discussions.

NACE Committees to Discuss Coating Requirements

Minimum requirements for application and materials for protecting pipe lines will be discussed by members of Technical Committee 2 on Pipe Line Corrosion of the National Association of Corrosion Engineers at Chicago, Illinois, in March. The committee meeting will be among some 50 scheduled to be held during the NACE eleventh annual conference and exhibition at Palmer House March 7-11.

Tentative minimum requirements are expected to be proposed by the unit committees on asphalt type coatings, coal tar coatings, wrapping materials and minimum current requirements for cathodic protection.

One T-2 unit committee expects to hear a report on tests designed to lead to development of suitable methods for evaluating internal corrosion in products pipe lines.

Petroleum Electrical Meet Success, Second Scheduled

After a successful first meeting on electrical applications in the petroleum industry, the AIEE committee in charge has decided to hold a second conference next September in Houston, Texas. The first meeting was held in Tulsa September 27-29.

Chairmen of three sub-committees in the American Institute of Electrical Engineers' petroleum industry committee recently named includes J. R. Ashley, Magnolia Pipe Line Company, Dallas, Texas, chairman of the production group; R. S. Cannon, Plantation Pipe Line Company, Atlanta, Georgia, chairman of the transportation group, and W. H. Dickinson, Standard Oil Development Company, Linden, New Jersey, chairman of the refining group.

pipe line personals

B. D. Leuty

G. McGrew

B. D. Leuty has been named to manage all pipe line transportation facilities of Cities Service Oil Company of Delaware and subsidiaries, including joint-interests of other lines. Leuty has also been elected vice president of Cities Service Pipe Line Company. **R. E. Koehl** and **William H. Sloan** are asssistants to the new manager. **Gerald McGrew** has been named manager of the company's crude oil supply division. **R. V. Sellers** and **George Nolley** will be assistants to McGrew.

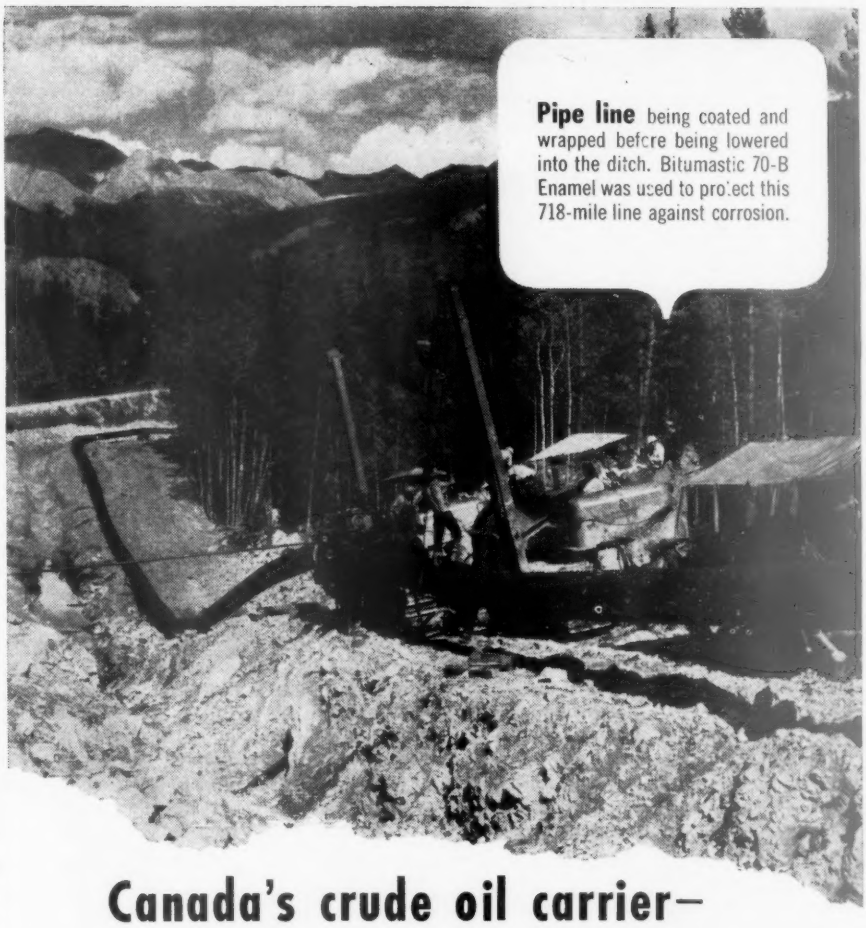
Leuty joined Cities Service in 1924 as a member of the company's engineer-training program. His first permanent assignment was in the engineering construction division, specializing in pipe line work. He was appointed assistant chief engineer in 1952. He has been special assistant to **C. S. Mitchell,** Cities Service Oil Company vice president, who has just been transferred to New York as manager of Cities' transportation and crude oil supply operations. Leuty is project manager for the new jointly-owned Badger products pipe line from East Chicago, Indiana, to Madison, Wisconsin. He is also vice president and general manager of the crude oil pipe line division of Cherokee Pipe Line Company.

McGrew, who will head up the company's crude oil supply operations, has been with the company since 1940.

Harry Nelson of Bartlesville will manage oil pipe line operations and **James W. Fagan** will manage the newly-organized products pipe line division. Nelson joined Cities Service in 1923. He was appointed general superintendent of Cities Service Pipe Line Company in 1942 and, one year later, was named acting manager of the pipe line company. In 1946, he was appointed manager.

Fagan, the new manager of products pipe line operations for Cities Service, is a long-time employee of Cities Service, having joined the company's engineer-training school in 1927. He has been resident engineer on the company's 20-in. line from Sour Lake, Texas, to Lake Charles, Louisiana, the Sour Lake-to-Houston oil line and the Badger products pipe line.

Charles W. Brown, chief clerk of measurement and research department of Texas Gas Transmission Corporation since July, 1952, has been promoted to assistant superintendent. Succeeding Brown as chief clerk is **Raymond S. Kramer,** former engineer in the department.



Pipe line being coated and wrapped before being lowered into the ditch. Bitumastic 70-B Enamel was used to protect this 718-mile line against corrosion.

Canada's crude oil carrier—

Trans Mountain Oil Pipe Line

—protected by Bitumastic 70-B Enamel

A river of oil now rolls all the way from Edmonton, Alberta, to Vancouver, British Columbia—a distance of 718 miles. Each day, more than 100,000 barrels of crude oil can be pumped through the Trans Mountain Oil Pipe Line that was recently completed.

Building this new 24-inch pipe line wasn't easy. Mountains had to be climbed. Rivers had to be forded —forded, at times, by using sealed sections of pipe as pontoons for temporary bridges. In some mountainous terrain, after using trucks, tractors and winches, pipe had to be carried into position, piece by piece.

A pipe line laid in such rough terrain deserves exceptional protection against corrosion. Recognizing this, Trans Mountain has coated the exterior surfaces of its new line, all 718 miles of it—with Bitumastic® 70-B Enamel. More than 20 years of satisfactory service protecting oil and gas pipe lines prove that Bitumastic 70-B Enamel is an excellent corrosion barrier.

For your next pipe-line project, specify Bitumastic Enamel. Get in touch with us for complete details and estimates.

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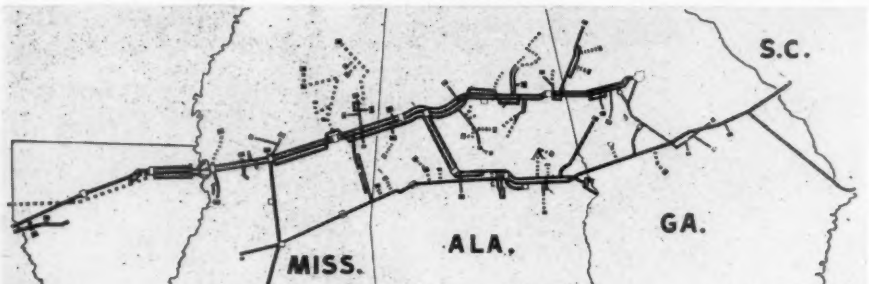

MILES OF PIPE

at end of	miles
1947	1899
1948	2120
1949	2218
1950	2625
1951	2840
1952	2970
1953	3855

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GLASS FIBERS INC. congratulates forward-looking Southern Natural Gas Company on its vigorous pipeline expansion program. As is well known, the cost of constructing an underground pipeline is tremendous. The cost of repairing or replacing it is sometimes even greater. Yet, for less than ½ of 1% of the original investment, Blue Flag-reinforced enamels will preserve a pipeline for years beyond its normal life. For a new folder on Glass Fibers' pipe wraps, write to Glass Fibers Inc., 1810 Madison Avenue, Toledo 2, Ohio.

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Personals

J. W. Cason

P. H. Hunter

Phelan H. Hunter has been elected president of Interstate Oil Pipe Line Company, replacing **George A. Wilson,** who has resigned. Organization changes also announced by Interstate include: **W. F. Davis,** elected a director; **J. W. Cason,** elected vice president and treasurer; **H. C. Bloomfield,** named comptroller; and **Frank R. Clark, Jr.,** elected secretary.

Hunter, former secretary-treasurer of Interstate, after practicing public accounting in New Orleans for six years, began his career in the oil business in 1932 with Standard Oil Company of Louisiana at New Orleans.

R. G. Pennington has been named assistant to the president of Tuscarora Pipe Line Company, Limited, with offices in Harrisburg, Pennsylvania. He replaced **Henry Hofmann,** who has retired after 36 years' service. Pennington comes to Tuscarora after 18 years in supply and distribution assignments with Esso Standard Oil Company in New York.

H. G. Mariner

Hobart G. Mariner has been appointed maintenance superintendent of the Service Pipe Line Company, Mariner, former manager of the company's Missouri division, succeeded **E. A. Slade** who resigned to accept a post as manager of the Warren Petroleum Corporation's pipe line department.

Frank C. Anderson has been appointed assistant general manager of operations of the domestic pipe line department of the Gulf Companies.

Anderson started with Gulf as an office boy in 1933. During World War II he saw military service on active duty with the Navy. Over the past several years, he served on the administrative staffs in the production and pipe line operations of the Gulf Companies and has most recently been serving as staff assistant to **J. H. Russell,** Gulf's vice president in charge of pipe lines for the United States.

W. L. Kygar, president of Continental Pipe Line Company, has been elected a member of the Board of Directors of Platte Pipe Line Company. Kygar succeeded **Charles A. Perlitz, Jr.,** senior vice president of Continental Oil Company, on the Platte Board.

John Williams, president of Williams Brothers, Tulsa, Oklahoma, recently was named a Flying Colonel by Delta-C&S airlines "in recognition of his outstanding contribution to the development of aviation."

Thomas M. Ragland has been named chief engineer of Pipe Line Anode Corporation. He is an electrical engineering graduate of the University of Kentucky and was associated with Phillips Petroleum Company during the past four years.

Personals

Two division managers and three district superintendents have been assgned to administer Service Pipe Line Company's new 625-mile, big-inch pipe line between Fort Laramie, Wyoming, and Freeman, Missouri.

The western segment of the new system will be added to the company's present Wyoming division. **R. R. Strand,** with headquarters at Casper, will manage this segment, which will extend from Fort Laramie to Kansas line.

The eastern segment of the new line, from the Kansas state line on the west to Freeman, will become part of the company's Kansas division. It will be managed by **C. A. Childers** with headquarters in Wichita. **Opal Blair,** formerly district superintendent of Scottsbluff, Nebraska, was named superintendent at Sterling, Colorado. The district will consist of the trunk line between the Wyoming state line and the Kansas state line, and gathering systems now under construction in the vicinity of Kimball, Nebraska.

A part of the former Nebraska division supervised by Blair, running from the Wyoming state line east to Scottsbluff, Nebraska, and the new line from Fort Laramie Station to the Wyoming state line, will be supervised by district superintendent **J. H. Keyes, Jr.,** of the Wyoming division's Salt Creek district.

In the Kansas division, that portion of the new line running from the Kansas state line on the west to Laton Station, near Natoma, Kansas, will become part of the Gorham district under district superintendent **Joseph Thomasson** with headquarters at Hays, Kansas.

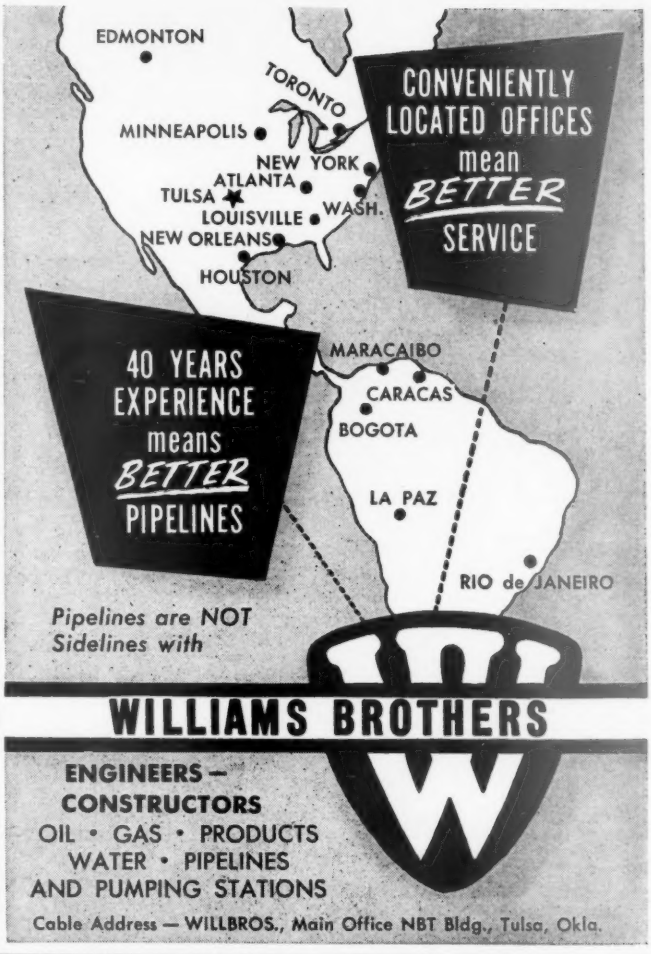
The remaining part of the line from Laton Station to Freeman will become a new district to be supervised by district superintendent **Paul A. Hardman** with headquarters in Topeka.

District superintendent **C. L. Wilson** of the former Kearney district in the old Nebraska division will remain temporarily at Kearney to supervise dismantling of the company's old line.

Harry C. Jones, former manager of the Service's Nebraska division, has been named manager of the Missouri division, with headquarters in Raytown, near Kansas City.

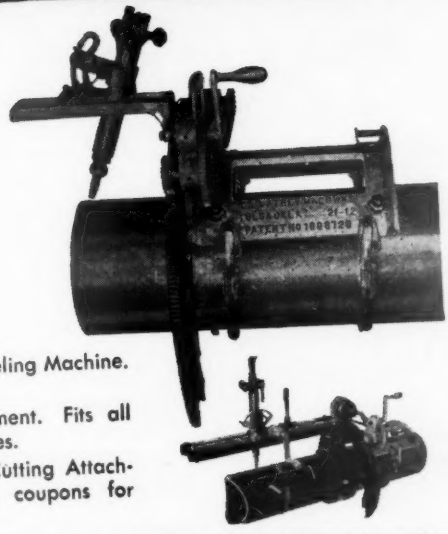
Announcement of the appointment of **Marshall Hyde** as distributor in the Michigan area is made by Pipeline Coating & Engineering Company, Inc., and Plico, Inc. Formerly national distributor for a gas odorant firm, Hyde is a veteran of many years' experience in the corrosion field.

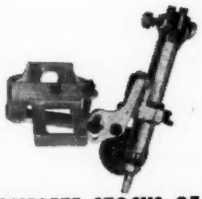
Pipe line Coating & Engineering Company, Inc., has also added to its staff in Houston, Texas, **Ben A. Hughes,** as office manager.



*Mathey PIPE CUTTING AND BEVELING MACHINES

- QUICKEST IN OPERATION
  - Just slips over pipe
  - No hinges or latches to open or close
- LIGHTEST WEIGHT
- FIVE MODELS (for pipe from 4" to 36 inches)
- ECONOMICAL
- FOR RENTAL OR PURCHASE





Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.

Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

*COMPLETE STOCKS OF PARTS FOR ALL MATHEY and MATHEY MANUFACTURED MACHINES IMMEDIATELY AVAILABLE

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C. A. MATHEY MACHINE WORKS, INC.
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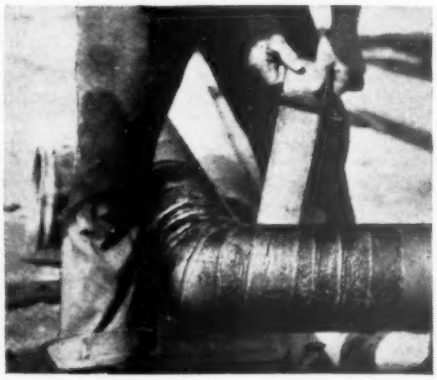
COMBAT CORROSION!

Specify TAPECOAT®

... the Original Coal Tar Coating in Tape Form for Pipe, Pipe Joints, Couplings and Tanks

TAPECOAT is a coal tar coating with a tar-saturated close-woven fabric as a carrier for speed of application. The coal tar is self-bonding and requires no foreign adhesives.

Because coal tar is nature's own protection against corrosion, TAPECOAT resists moisture, acids, alkalis, soil stress, electrolysis, chemical fumes, fly ash, salt water, salt-laden air, barnacles, and other severe corrosive and abrasive conditions above and below ground.



TAPECOAT is clean to handle and easy to apply by spiral or "cigarette" wrapping with the use of a torch to bleed the coating to insure a continuous bond. It cuts maintenance and replacement costs.

TAPECOAT is sized to the job — comes in rolls of 2", 3", 4", 6", 18" and 24" widths to meet specific requirements on pipe, pipe joints, couplings, tanks, cable, conduit and other vulnerable steel surfaces.

PROVED IN SERVICE SINCE 1941

TAPECOAT has proved its dependability over the years in serving gas and oil companies, railroads, telephone companies, air lines, shipbuilders and operators, water and sewage works, chemical and industrial plants, engineers and contractors . . . providing continuing protection against corrosion.

Write for descriptive brochure and prices.

The TAPECOAT Company

Originators of Coal Tar Tape Protection

1533 Lyons Street, Evanston, Illinois

With the PIPE LINE

● **Anderson Bros. de Venezuela, S.A., 3200 Wheeler St., Houston, Texas.** Has approximately 27 miles 24-in. crude line in Venezuela for *Shell de Venezuela Pipe Line Company*. Earl Saulsman, superintendent.

● **Arey Construction Company, Box 1501, Pampa, Texas.** Has 100 miles 6-in. for *Shamrock Oil and Gas Company*, Amarillo to Lubbock, Texas. H. V. Gorman, superintendent.

● **Baughman Contracting Company, Box 569, R. D. #1, Cumberland, Maryland.** Has large amount various sizes for *Manufacturers Light and Heat Company, West Virginia Natural Gas, and Cumberland and Allegheny Gas Company*.

● **Brown and Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has 30 miles 16-in. underwater crude line for *Shell de Venezuela Pipe Line Company*, Lake Maracaibo. E. R. Jackson, superintendent.

● **M-R Construction Company, Box 484, Wichita, Kansas.** Has 71 miles of 10-in. for *Great Lakes Pipe Line Company*, Kansas City to Burlingame, Kansas. John Tarpley, superintendent, Topeka, Kansas.

● **McVean and Barlow, Inc., Odessa, Texas.** Has 24 miles of 8 and 10-in. for *Texas-New Mexico Pipe Line Company*, Midland County, Texas.

● **River Construction Corporation, 6100 Camp Bowie Boulevard, Fort Worth, Texas.** Has 81 miles, 6-in. for *Champlin Refining Company*, Enid to Oklahoma City, Oklahoma. Myrl Tatom, superintendent, Edmond, Oklahoma. Also has 66 miles, 8 and 12-in. gas line, Pecos County to Reeves County, Texas, for *Pecos Growers Gas Company*.

● **Ray L. Smith and Son, Inc., Box 391, El Dorado, Kansas.** Has 91 miles of 10-in. for *Great Lakes Pipe Line Company*, Burlingame to El Dorado, Kansas. Dewey Whitworth and Carl Colvin, superintendents, El Dorado office.

● **Station Construction Company, Box 13174, Houston, Texas.** Has pump station for *Cherokee Pipe Line* products system, Jenks, Oklahoma; gas turbine compressor station, for *Trunkline Gas Company*, Edna, Texas; pump station and terminal, *Shell Pipe Line Corporation*, products line, Norco, Louisiana; terminal, *Standard Oil Company of Texas*, Albuquerque, New Mexico; metering stations, *Badger Pipe Line*, Rockford, Illinois.

● **L. E. Farley, Inc., 5247 Buffalo, Houston, Texas.** Has 27 miles, 12-in. for *Transcontinental Gas Pipe Line Company*, Orange, Texas, to Texas-Louisiana border. L. W. Berton, superintendent, Vinton, Louisiana.

● **Fulghum Contracting Corporation, Box 1181, Harrisburg, Pennsylvania.** Has 51 miles of 10-in. for *Sohio Petroleum Corporation*, Lima to Fostoria, Ohio. G. E. Beaver, and John Wells, superintendents at Findlay and Bluffton, Ohio.

● **Foster-Wheeler Corporation, 165 Broadway, New York 6, New York.** Has overall supervision of a 1920-mile NATO pipe line system in Europe.

● **H. C. Price Company (Somastic Division), Box 1111, Bartlesville, Oklahoma.** Has contract for coating 163 miles, 10¾-in. OD pipe for *Great Lakes Pipe Line Company*. Railhead locations at Topeka and Emporia, Kansas.

CONTRACTORS

● **Engineering-Construction Company, 402 North Cheyenne, Tulsa, Oklahoma.** Has 150 miles, 6 to 10-in. gas line for *Southeast Alabama Gas District.* Two spreads: Gene Coulter, superintendent at Eufaula, Alabama, and Jim Williams, superintendent, Headland, Alabama.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has 65 miles of 12-in. products line for *Shell Pipe Line Corporation,* Baton Rouge to Norco Refinery (New Orleans), Louisiana. Job delayed due to right-of-way acquisition. Also has 57 miles of 20-in. gas line for *Tennessee Gas Transmission Company* between Kinder and Pecan Island, Louisiana.

● **Merritt-Chapman & Scott Corporation, 260 Madison Avenue, New York 16, New York.** Has 53 miles of 8 to 24-in. between Bombay and Butcher Island for *Bombay Port Trust,* India. Also 16 miles of 16-in. between refinery and Sydney for *Australian Oil Refining.*

● **Gragg, Canada, Ltd., 295 Kipling Ave. South, Toronto 18, Ontario.** Has two 16-in. river crossings on Red River south of Winnipeg for *Winnipeg and Central Natural Gas.* Also approximately 2 miles of 12-in. loop line for *Consumers Gas Company* in Toronto.

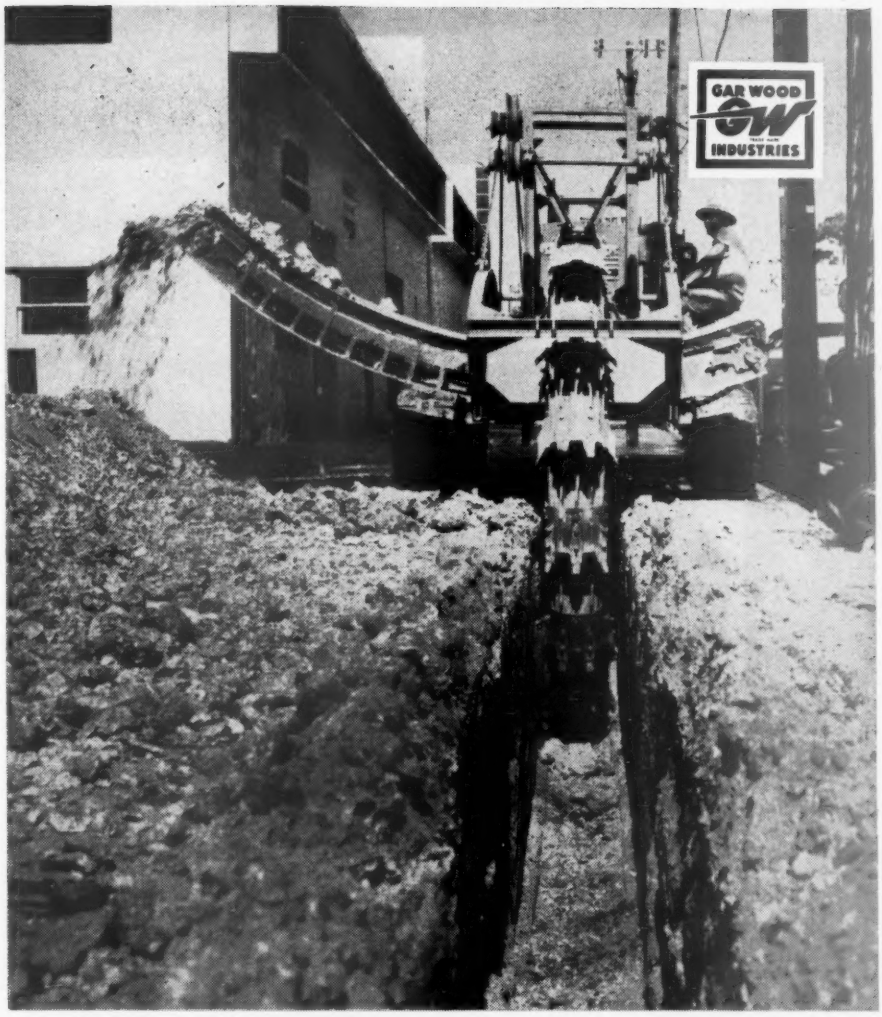
● **Missouri Valley Dredging, 222 William Street, Omaha 8, Nebraska.** Has take-off facilities from Harbor Pipe Line at Trenton, New Jersey, for *Sinclair Pipe Line;* 4 miles of 8-in. at Trenton for *Gulf Oil,* and river crossing at McConnellsville, Ohio, for *Tennessee Gas Transmission,* 1254 ft of 26-in.

● **Ferguson Construction Company, Eunice, New Mexico.** Has 43 miles of 5 to 8-in. crude line for *Texas-New Mexico Pipe Line Company* in Eastern New Mexico and West Texas. W. W. Shipley, superintendent, Lovington, New Mexico.

● **Panama-Williams Company, Melrose Building, Houston, Texas.** Has 120 miles, 12-in. for *Texas Company* in Colombia, S. A. Job temporarily shut down. Also has 93 miles of 5-in. products line for *Goliad Petroleum Corporation,* Texas City to Halletsville, Texas. H. Hall, superintendent, El Campo, Texas.

MEN
EXPERIENCE
EQUIPMENT
to finish your pipeline job on schedule

SINCE 1926



CONTRACTOR RUNS 100 DAYS AHEAD OF SCHEDULE ON CORAL GABLES SEWER JOB

NEW BUCKEYE 315

Digs 1700 ft. daily thru solid coral rock!

Phenomenal performance records have been set by this new Buckeye 315 on a project involving digging more than 300,000 ft. of sanitary sewage lines in Coral Gables, Fla. Working in "oolite", the technical name for the coral rock upon which the city is built, Morris Prosser, Inc. has averaged over 1700 ft. of trench, 24" wide and from 4' to 6' deep, every day. This record has helped the contractor to gain over 100 days on his original estimated schedule in order to finish the job in *less than half* the time allowed.

Recently added to the Buckeye line, the new model 315 is a wheel-type machine designed for the pipeline and utility field. Like every machine in the line, from the famous model "51" to the smallest, the "315" is built to stand up under the toughest usage and earn increased profits for its owner.

FOR FAST SERVICE TO PIPELINERS! The Gar Wood-Buckeye branch in Tulsa is staffed by trained, experienced service crews—stocks thousands of parts ready for immediate shipment—operates around the clock to keep every Buckeye ditcher constantly on the job. A phone call brings immediate action!

No. 558

GAR WOOD INDUSTRIES, INC.
WAYNE, MICHIGAN

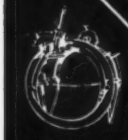
PIPELINE KETTLES

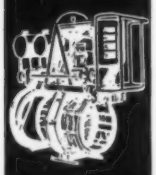
STATIONARY CLEANING & PRIMING MACHINES

YARD PIPE RECONDITIONING EQUIPMENT

PORTABLE GENERATORS

ROAD BORING MACHINES


CUTTING & BEVELING MACHINES


CLEANING & PRIMING MACHINES

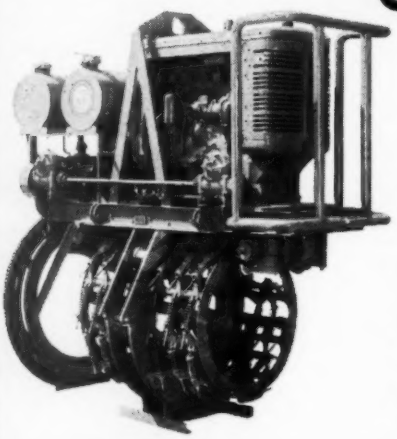
PORTABLE BUFFING UNITS

ROLLING RIGS

Model CPF—for 2" to 8" pipe.
Model M —for 3" to 14" pipe.
Model K —for 16" to 26" pipe.
Model R —for 30" to 31" pipe.

CROSE LINE-TRAVELING CLEANING AND PRIMING MACHINE

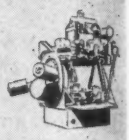
Rugged and Dependable



The most rugged and dependable cleaning and priming machine on the line . . . equipped with dual multi-speed transmissions providing greater flexibility of control. Interchangeable cleaning and priming assemblies permit each model to process a wide range of pipe sizes.

PIPELINE CRADLES

INTERNAL LINE-UP CLAMPS


COATING & WRAPPING MACHINES

PATCH KETTLES

ENDLESS PIPE BELT SLINGS

m.j. crose Manufacturing Company, Inc.

2715 DAWSON ROAD • TULSA, OKLAHOMA • U.S.A.

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SPECIALIZED EQUIPMENT FOR THE PIPELINE INDUSTRY

45

45 NELSON CONTROL BOARDS PROVIDE *AUTOMATIC,* EXPLOSION-PROOF CONTROL FOR NEW PIPE LINE . . .

45 Nelson control boards have been installed for automatically controlling compressor engine operations in the compressor stations which are located along a new gas pipe line system. The pipe line extends for a distance of 1,160 miles.

Photo, at left, shows front view of one of the Nelson control boards. Note the following features: explosion-proof indicating lights; pressure gauges; valve motor control buttons inserted in the mimic piping diagram.

Let us quote on your requirements for custom-engineered control boards. Write for descriptive bulletin #712.

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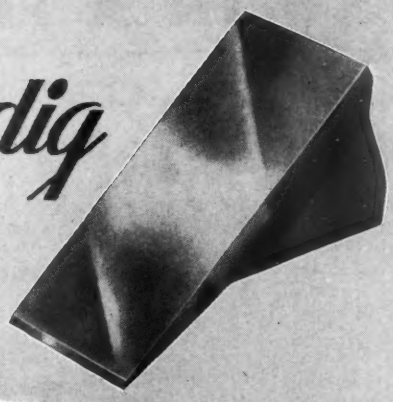
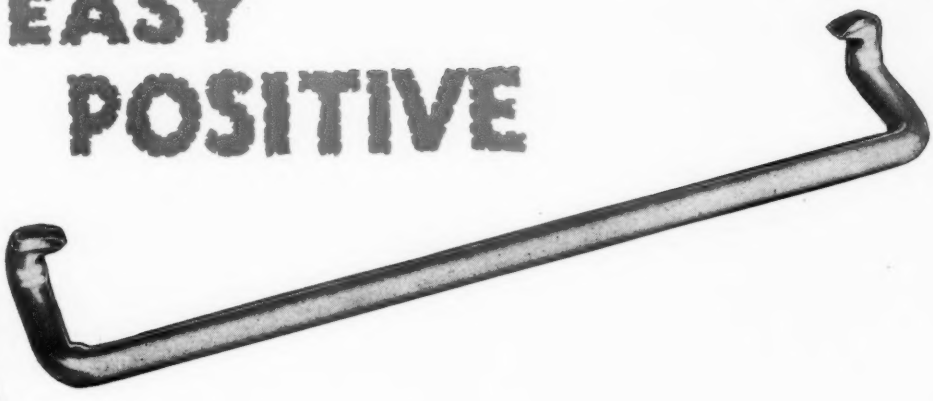
Teeth that really dig

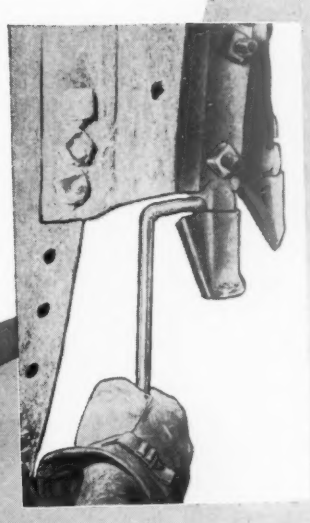


QUICK
EASY
POSITIVE



POINT REMOVER TOOL

Tool is offset for easy starting. The shape of the tool provides a rocking action which gives a positive lift, releasing the point.



H&L TOOTH COMPANY

1540 SO. GREENWOOD AVE. MONTEBELLO, CALIFORNIA

You Can Lead a Horse to Water But . . . . . .

WHEN the United States Supreme Court throttled the gas producer with price fixing, several interstate pipeline projects were postponed. The builders still want to construct them but they no longer have assurance of an adequate gas supply. Rather than sell under prices fixed by the Federal Power Commission, many producers declined to make contracts.

In other instances, some producers discontinued deliveries under existing contracts which provided for such action in case of Federal price fixing. Some who fought for the price-fixing decision promptly besought the Federal Power Commission to compel producers to continue deliveries. This seems like another issue for the courts.

The man with gas reserves not under contract cannot be compelled to enter into a contract, which means the construction of interstate transmission systems will move at a slow pace until the Natural Gas Act is clarified.

What will these gas producers do with their gas? Those who anticipate that the producer will, in time and of necessity, have to submit to price fixing should have a look around. Two Southwestern plants, one for making chemicals, the other for aluminum ore reduction, use more gas per day than all of the homes in Detroit, Milwaukee and Kansas City, combined.

Natural gas is sometimes called the "world's outstanding raw chemical." It is used in making nylon salts; can be converted into acetylene, and its hydrogen content can be combined with nitrogen (from the air) to make ammonia. As a low-cost, efficient fuel for our homes, our industries and our people, natural gas has no superior.

Rather than sell it at a government-fixed price, many producers are determined to use or sell it within the state where it is produced. The finished chemicals made from and with it can move across state lines without price control. Why not natural gas, whose benefits are anxiously sought by so many millions of Americans?

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General Contractors

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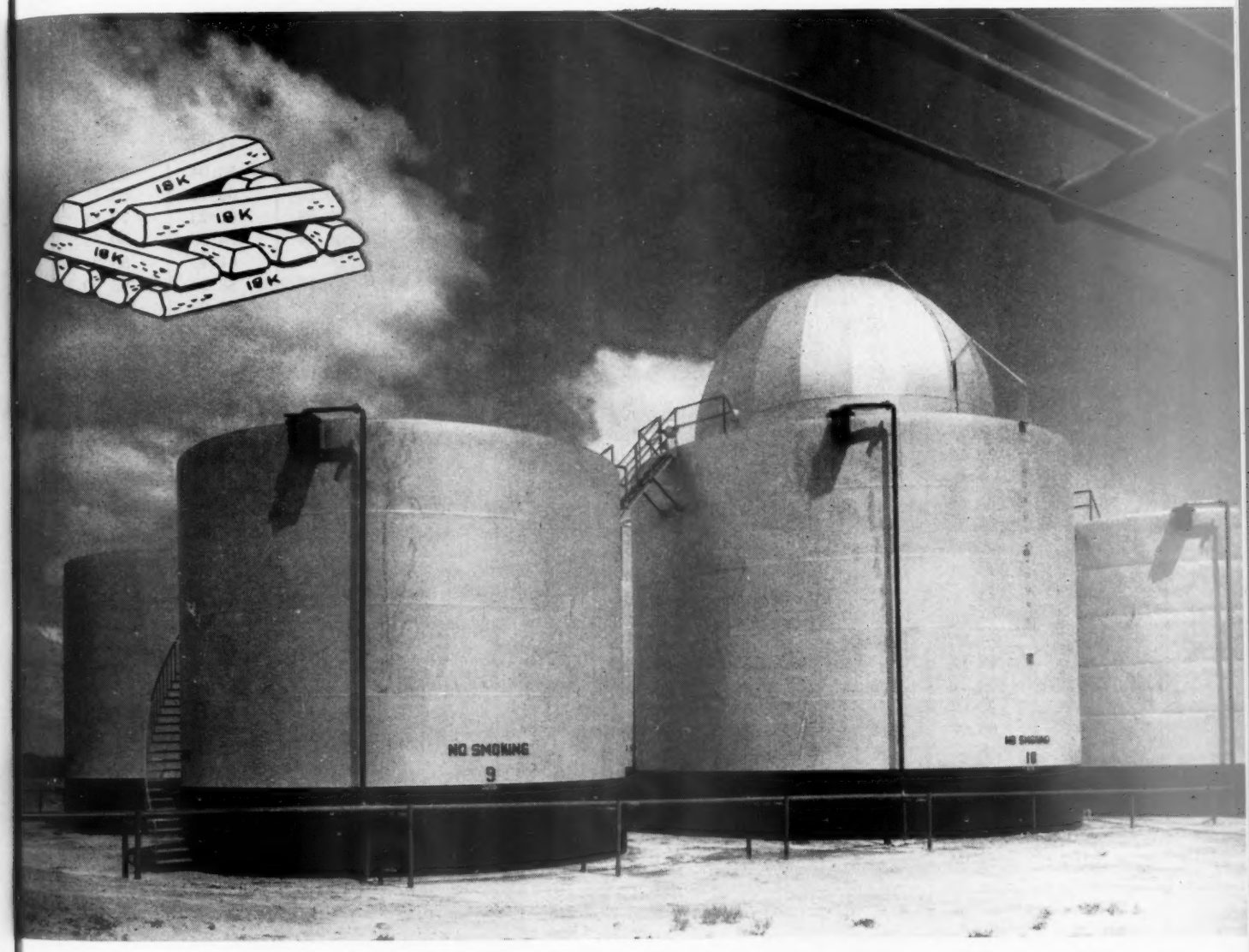
OIL • GAS • GASOLINE • WATER PIPE LINES • 2707 FERNDALE, HOUSTON 6, TEXAS

IF GOLD VAPORIZED...



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• Would you just sit and watch it go? That's exactly what's happening every time one of your fixed-roof tanks, that store volatile hydrocarbons, vents vapor to the atmosphere. Profits are disappearing if you're just sitting and watching. A Hortondome® Roof, like the one above, acting as the central unit in a vapor conservation system and interconnected to fixed-roof tanks, will store displaced vapor from the tanks under a flexible hemispherical membrane inside the dome. When conditions causing the displacement are reversed, the vapor will return to the tanks . . . and return profits to you. Complete information on Hortondome Roofs may be obtained by writing our nearest office.

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XUM

STORAGE CAPACITY OF GAS SANDS, THOUSAND CU. FT. PER ACRE FT.
(Temperature 60 deg. fahr.)

Bottom hole pressure, lb. per sq. in. gauge	Percent porosity								
	10	12	14	16	18	20	22	24	26
10	7.313	8.776	10.24	11.70	13.16	14.63	16.09	17.55	19.01
20	10.27	12.32	14.38	16.43	18.49	20.54	22.60	24.65	26.70
30	13.23	15.87	18.52	21.16	23.81	26.46	29.10	31.75	34.39
40	16.18	19.42	22.66	25.90	29.13	32.37	35.61	38.84	42.08
50	19.14	22.97	26.80	30.63	34.46	38.28	42.11	45.94	49.77
60	22.10	26.52	30.94	35.36	39.78	44.20	48.62	53.04	57.46
70	25.06	30.07	35.08	40.09	45.10	50.11	55.12	60.14	65.15
80	28.01	33.62	39.22	44.82	50.42	56.03	61.63	67.23	72.84
90	30.97	37.17	43.36	49.55	55.75	61.94	68.14	74.33	80.52
100	33.93	40.71	47.50	54.29	61.07	67.86	74.64	81.43	88.21
110	36.89	44.26	51.64	59.02	66.39	73.77	81.15	88.53	95.90
120	39.84	47.81	55.78	63.75	71.72	79.69	87.65	95.62	103.59
130	42.80	51.36	59.92	68.48	77.04	85.60	94.16	102.72	111.28
140	45.76	54.91	64.06	73.21	82.36	91.51	100.67	109.82	118.97
150	48.71	58.46	68.20	77.94	87.69	97.43	107.17	116.91	126.66
160	51.67	62.01	72.34	82.67	93.01	103.34	113.68	124.01	134.35
170	54.63	65.55	76.48	87.41	98.33	109.26	120.18	131.11	142.04
180	57.59	69.10	80.62	92.14	103.66	115.17	126.69	138.21	149.72
190	60.54	72.65	84.76	96.87	108.98	121.09	133.20	145.30	157.41
200	63.50	76.20	88.90	101.60	114.30	127.00	139.70	152.40	165.10
210	66.46	79.75	93.04	106.33	119.62	132.92	146.21	159.50	172.79
220	69.42	83.30	97.18	111.06	124.95	138.83	152.71	166.60	180.48
230	72.37	86.85	101.32	115.80	130.27	144.74	159.22	173.69	188.17
240	75.33	90.40	105.46	120.53	135.59	150.66	165.72	180.79	195.86
250	78.29	93.94	109.60	125.26	140.92	156.57	172.23	187.89	203.55
260	81.24	97.49	113.74	129.99	146.24	162.49	178.74	194.99	211.23
270	84.20	101.04	117.88	134.72	151.56	168.40	185.24	202.08	218.92
280	87.16	104.59	122.02	139.45	156.89	174.32	191.75	209.18	226.61
290	90.12	108.14	126.16	144.19	162.21	180.23	198.25	216.28	234.30
300	93.07	111.68	130.30	148.92	167.53	186.15	204.76	223.37	241.99
310	96.03	115.24	134.44	153.65	172.85	192.06	211.27	230.47	249.68
320	98.99	118.78	138.58	158.38	178.18	197.97	217.77	237.57	257.37
330	101.94	122.33	142.72	163.11	183.50	203.89	224.28	244.67	265.06
340	104.90	125.88	146.86	167.84	188.82	209.80	230.78	251.76	272.74
350	107.86	129.43	151.00	172.57	194.15	215.72	237.29	258.86	280.43
360	110.82	132.98	155.14	177.31	199.47	221.63	243.80	265.96	288.12
370	113.77	136.53	159.28	182.04	204.79	227.55	250.30	273.06	295.81
380	116.73	140.08	163.42	186.77	210.12	233.46	256.81	280.15	303.50
390	119.69	143.63	167.56	191.50	215.44	239.38	263.31	287.25	311.19
400	122.65	147.17	171.70	196.23	220.76	245.29	269.82	294.35	318.88
410	125.60	150.72	175.84	200.96	226.08	251.20	276.33	301.45	326.57
420	128.56	154.27	179.98	205.70	231.41	257.12	282.83	308.54	334.26
430	131.52	157.82	184.12	210.43	236.73	263.03	289.34	315.64	341.94
440	134.47	161.37	188.26	215.16	242.05	268.95	295.84	322.74	349.63
450	137.43	164.92	192.40	219.89	247.38	274.86	302.35	329.84	357.32
460	140.39	168.47	196.54	224.62	252.70	280.78	308.85	336.93	365.01
470	143.35	172.01	200.68	229.35	258.02	286.69	315.36	344.03	372.70
480	146.30	175.56	204.82	234.08	263.35	292.61	321.87	351.13	380.39
490	149.26	179.11	208.96	238.82	268.67	298.52	328.37	358.22	388.08
500	152.22	182.66	213.10	243.55	273.99	304.44	334.88	365.32	395.77
550	167.00	200.40	233.81	267.21	300.61	334.01	367.41	400.81	434.21
600	181.79	218.15	254.51	290.86	327.22	363.58	399.94	436.30	472.65
650	196.58	235.89	275.21	314.52	353.84	393.15	432.47	471.78	511.10
700	211.36	253.63	295.91	338.18	380.45	422.72	465.00	507.27	549.54
750	226.15	271.38	316.61	361.84	407.07	452.30	497.53	542.76	587.99
800	240.93	289.12	337.31	385.50	433.68	481.87	530.06	578.24	626.43
850	255.72	306.86	358.01	409.15	460.30	511.44	562.59	613.73	664.87
900	270.51	324.61	378.71	432.81	486.91	541.01	595.11	649.22	703.32
950	285.29	342.35	399.41	456.47	513.53	570.59	627.64	684.70	741.76
1000	300.08	360.09	420.11	480.13	540.14	600.16	660.17	720.19	780.21

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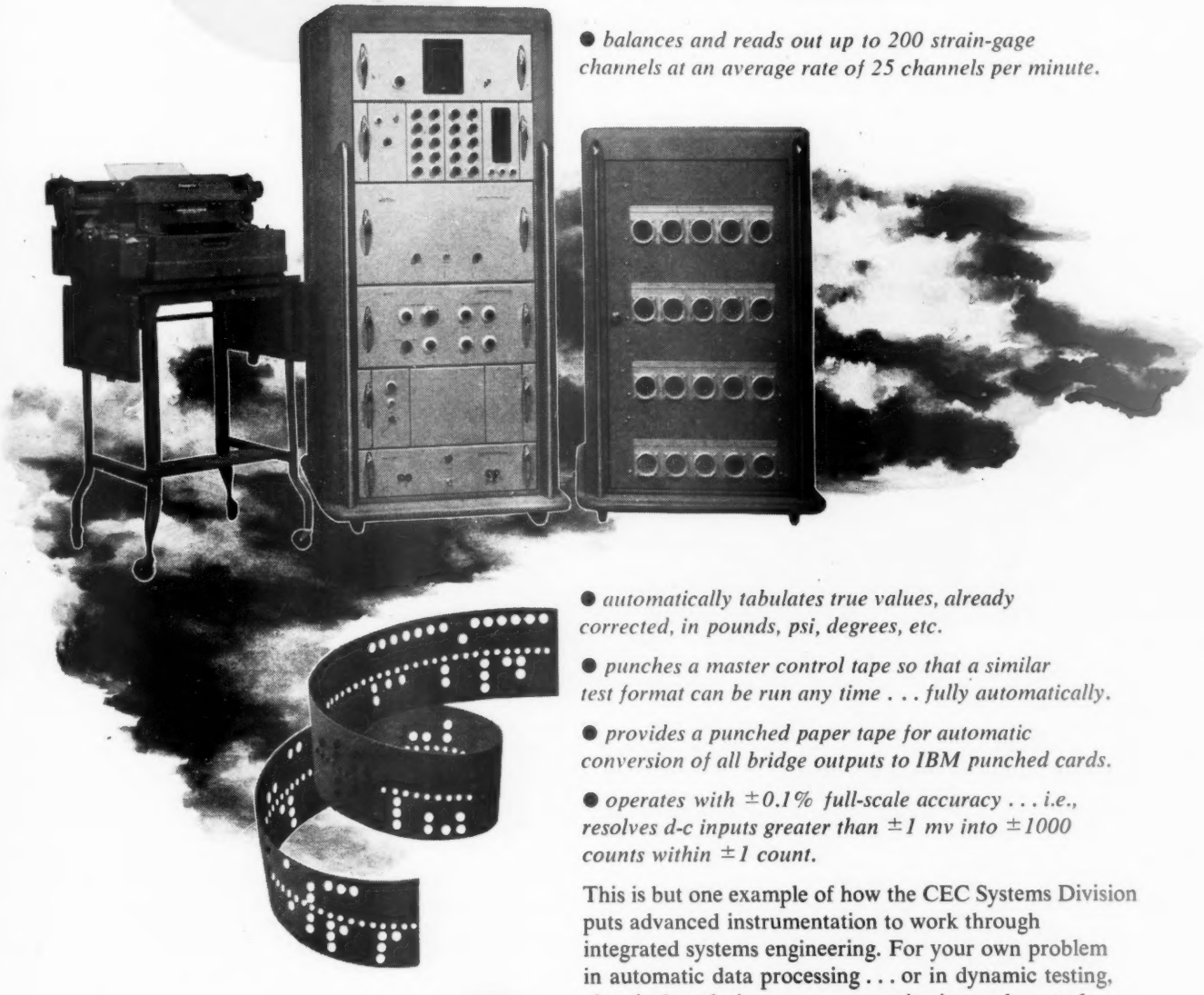

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EXCLUSIVE Gas storage pools are vital to meet demand that fluctuates widely both by day and seasons — Here are some of the practical engineering problems to be met when a reservoir must be operated at high pressures

How to Construct Underground Gas Storage

Palmer H. Montgomery

EVER increasing use of natural gas, particularly for space heating, has given rise to constantly larger demands for this fuel and with the decline of production in the East there is a continuous need for additional storage pools. Depleted gas fields can frequently be transformed into excellent underground storages.

This paper deals with some of the practical problems encountered in construction of an underground gas storage in one particular depleted Oriskany sand field. This storage was designed for maximum formation pressures of 2200 psi, which was the original rock pressure of the pool. The storage will have a minimum deliverability of 225,000 Mcf per day when the storage contains the minimum of active gas. The cushion gas is estimated to be 22,500,000 Mcf and the active or top gas will be 22,500,000 Mcf, when the storage is filled to capacity.

Because the storage will be operated at such high pressures, and because so many of the wells were abandoned and plugged with all sorts of materials, and because of serious caving formations, the construction of this storage presented a great many unusual and interesting engineering problems.

These wells, when originally drilled, were usually equipped with 8⅝-in. OD 32-lb casing, set at average depths of 600 ft to shut off fresh water and 7-in OD 26-lb production casing set at depths of 5100 to 5200 ft. The lower 500 ft of production casing was usually cemented. As the production declined, a great number of the wells were plugged and abandoned. At the time of abandonment, as much casing as possible was recovered by shooting or cutting the production casing just above the top of the cement, leaving a cemented casing stub in the hole.

The fresh water casing was also recovered, and brush, cement, and numerous other types of plugs were placed at various depths in the hole. From our experience at most of the wells, it seemed that many other materials, which happened to be around the derrick floor, apparently were thrown in the hole during plugging operations.

During the construction of the storage it was necessary to condition every active well and to resurrect and reclaim every abandoned well. Where reclamation was impossible, they were re-plugged.

This paper covers the following four major construction features:

Reclaiming abandoned wells
Re-plugging
Conditioning active wells
Drilling new wells

RECLAIMING OLD WELLS

The general method for treatment of an abandoned hole had one of two goals, (1) to reclaim it for an active storage well, and (2) in the event this was not possible, to seal and properly abandon it against loss of gas. The following is a general outline of the procedure used for reclamation of an abandoned well:

1. Install new 8⅝-in. or 9⅝-in. casing to shut off fresh water.
2. Clean out the hole through caving formations to the point where the old production casing (usually 7-in. OD) was shot or ripped off.
3. Locate top of old casing stub.
4. Join a new string, where possible, of 7-in. casing with this old 7-in. stub, i.e., effect a jointure.
5. Clean out the hole after jointure down through the storage sand.
6. Install a new string of 5½-in. or 7-in. casing to be used as a production or flow casing.
7. Test the production casing and complete the hole to be used as an active well.

Fresh Water Casing. To clean out to the orignal casing seat and re-run water casing, a small wheel-mounted cleaning out machine was used. Little difficulty was encountered in this operation and with the use of 12-in. tools the hole was cleaned out to the casing seat through cement and other materials used for bridging. In several wells it was necessary to ream the hole to permit the casing to go to the casing seat, and in every old hole a new casing seat was made. Some trouble was encountered with gas pockets below bridges, and on one occasion the tools were blown out of the hole. After running new 8⅝-in. 32-lb casing or 9⅝-in. 36-lb casing it was cemented with approximately 75 sacks by the circulation method, although actual circulation to the surface was never reached. Various types of lost-circulation materials were used, but none was successful in bringing the fluid to the surface. In one instance the pump pressure increased rapidly and the casing started to rise out of the hole, but the fluid did not return to the surface.

The top of the cement in the annular space outside the casing, generally found at approximately 300 ft from the bottom of the casing, was located by a temperature survey.

After the water was bailed and the cement drilled out, a bridge was set a few feet below the casing to test the casing seat for leakage of water.

Treatment of Caving Formations. One of several types of rigs was moved over the hole at this point of operation. Although standard cable tool rigs were

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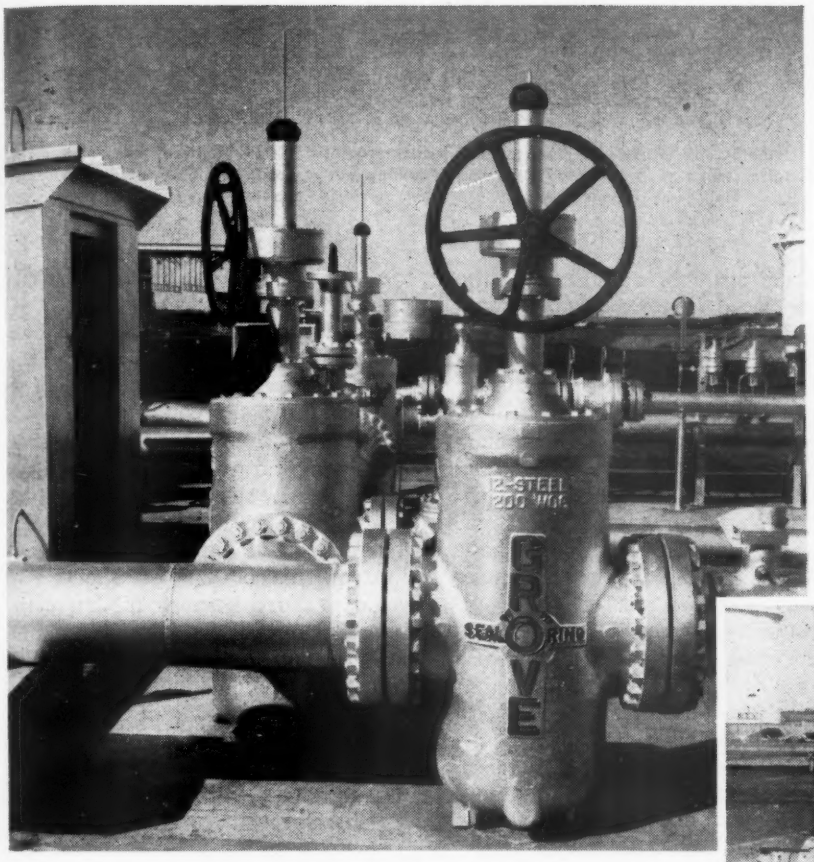

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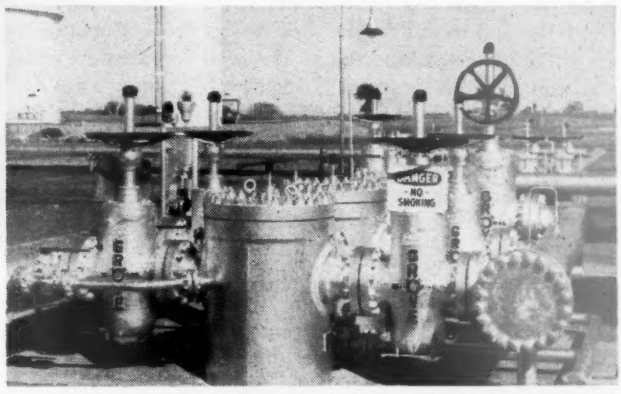

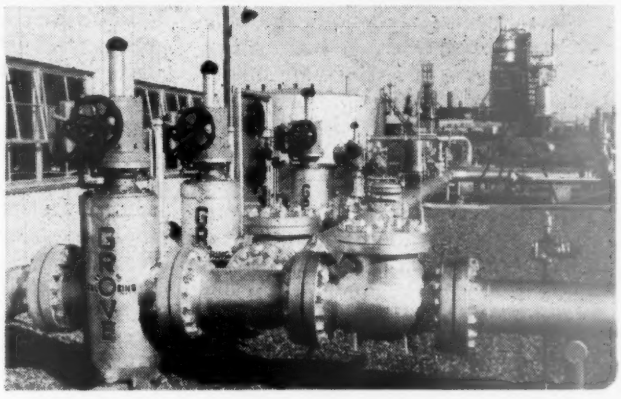

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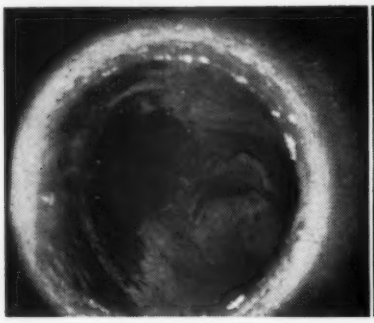


FIG. 1. Bottom hole photograph of casing stub showing lip covering entrance to casing. Note hole drilled alongside casing.

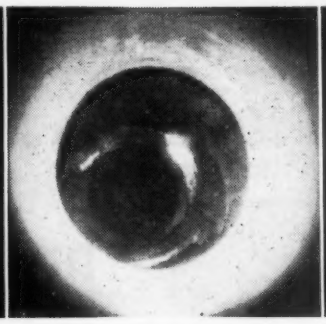


FIG. 2. Bottom hole photograph of casing stub. Note spiral effect of top.

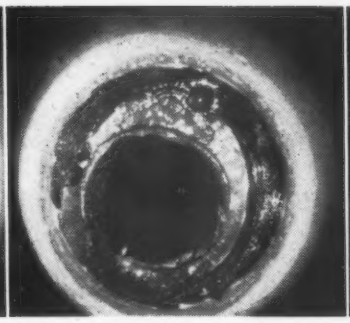


FIG. 3. Bottom hole photograph of casing stub. Note ring of drilling mud around casing.

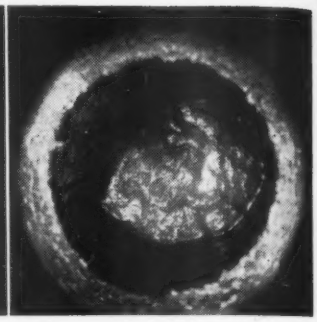


FIG. 4. Bottom hole photograph showing drilling mud which disguised casing stub.

most frequently used, large spudders and other drilling machines were also used, and with success.

Little difficulty was experienced with caving holes between the water casing seat and the Tully lime, at a depth of about 4300 ft. Below this depth, caving formations were encountered, which created probably the biggest single source of trouble in reclaiming the old holes.

Many strings of tools, bailers, and wire lines were lost in this portion of the hole, and months were spent in removing or sidetracking them. One well had unusually large cave holes which the caliper surveys showed to be larger than 50 in. in diameter in some places. At this hole, troublesome caving formations persisted throughout the entire length of the hole, from the water casing seat to the cap rock immediately overlying the storage horizon. In addition to the strings of tools, bailers, and wire lines that were lost and removed, the record of this well reveals that the following tools or materials disappeared in the huge cave holes and were never recovered: One 7-in. bailer, three 5½- in. bailers, 600 ft of wire line, a wire line cutter, 300 ft of armed cable, and a gun perforator. These were permanently side-tracked.

The cave holes were so large in this well that 2100 sacks of cement were used in cementing the production casing and the fill-up in the annular space outside the casing was only 500 ft.

Several methods were used to combat caving formation. One method was the use of drilling compounds which were mixed with water and dumped from the top of the hole. This not only water-proofed the walls of the hole but also served as a drilling fluid. Another successful method was to fill the hole with from 50 to several hundred feet of gel and clean out, using this fluid. A third method used was to cement back and re-drill the section of the hole where caving was troublesome. Still another method was the use of the "cement bomb."

This "cement bomb," specifically designed on this job, consisted of dry cement placed in the bottom section of a cylinder and the top section filled with gas at 300 psig. The tools were run on a sand line to the desired depth where it was tripped, rupturing a disc. This released the gas pressure, forcing the dry cement out through a spray, dusting the wet walls of the hole, which action formed a thin layer of cement on the walls. This tool works to the best advantage when used as a preventive measure rather than a cure.

Location of Casing Stub. When the cleaning out had progressed to approximately 60 to 100 ft. above the point where the top of the stub was expected, the 8-in. drilling bit with a normal cutting edge was removed and a "pointed bit" was used to prevent damage to the top of the stub.

It was difficult accurately to determine the depth of the top of the stub and whether the tools were working inside or outside of it. Impression blocks were used extensively and the markings of the tools were closely examined after each run. Electric logs and magnetic logs were used to locate, where possible, its exact depth. Caliper surveys were run to point out whether the tools were working on the inside or outside of the old stub.

A bottom hole camera was devised for this project specifically to help solve these problems. At this point in the reclamation, a bottom hole photograph was taken to determine the condition and what treatment should be given the top of the stub in order to prepare it for jointure.

Fig. 1, 2, 3, and 4 are bottom hole photographs taken 4000 ft underground, showing the condition of 4 holes at the casing stub.

Methods of Jointure. Two methods were employed to make a jointure between the new string of casing and the old stub. "Sleeve" jointure generally consisted of running a string of new 7-in. on the bottom of which was welded a short sleeve of an ID greater than 7 in. As the pipe was lowered in the hole the sleeve telescoped over the stub of old original 7-in. left in the hole.

Even though the top of the stub appeared to be in good enough shape to receive the sleeve, it was usually necessary to dress it up by smoothing and straightening with various tools. Some of these were especially devised for this purpose. One of the most useful tools was a guided rasp which consisted of a regular spud with rasps welded on the inside of the blade.

The tool was guided by a 4-in. pipe guide, generally 4 to 12 ft. longer than the spud itself. As the guide moved up and down inside of the stub the rasps worked on the outside. In this manner it was prepared for the sleeve.

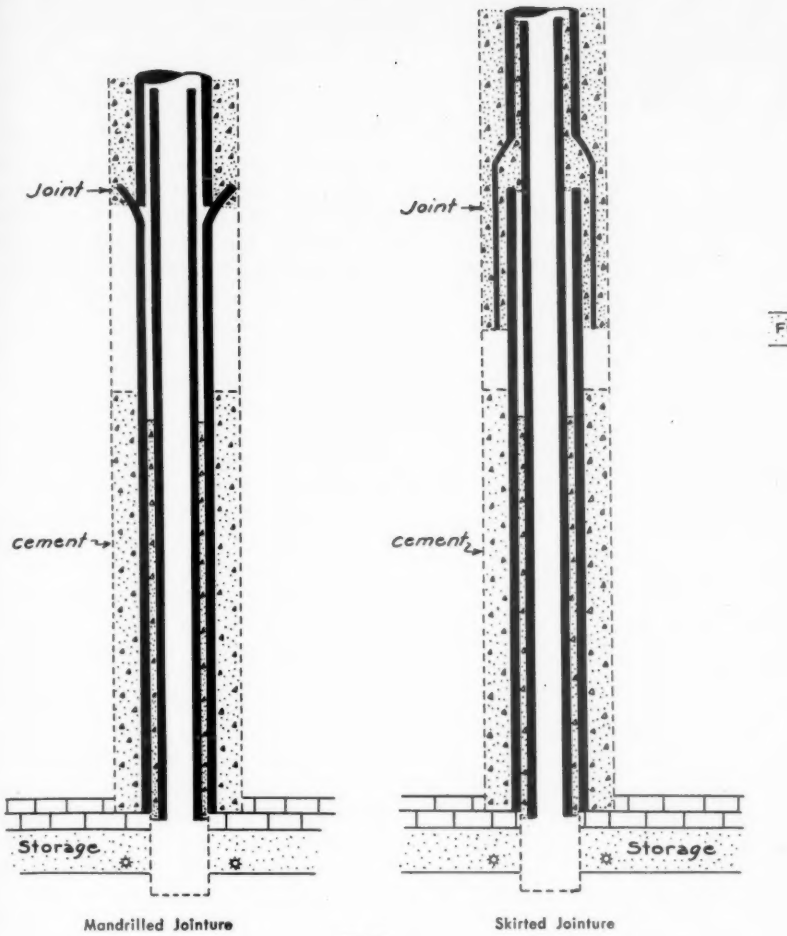
Many other types of tools were also used in this operation. Such tools as ¾-round spuds with rasps, ⅓ to ⅔ tapered spuds with rasps, and other spuds with cutting teeth on one edge were used to prepare the top of the stub for jointure. The inside of the stub was dressed up by running proper size swages which were also guided.

Frequently the top of the stub was off center from the rest of the hole and it was necessary to make offsets in the guide so that it would enter the stub. A knuckle sub was often used in conjunction with the bent guide for the same purpose. Progress was followed with the use of impression blocks and bottom hole photographs.

Before attempting to run a sleeve on the bottom of the new string of casing, a trial run was made with the sleeve on the end of the tools to make certain

The Author

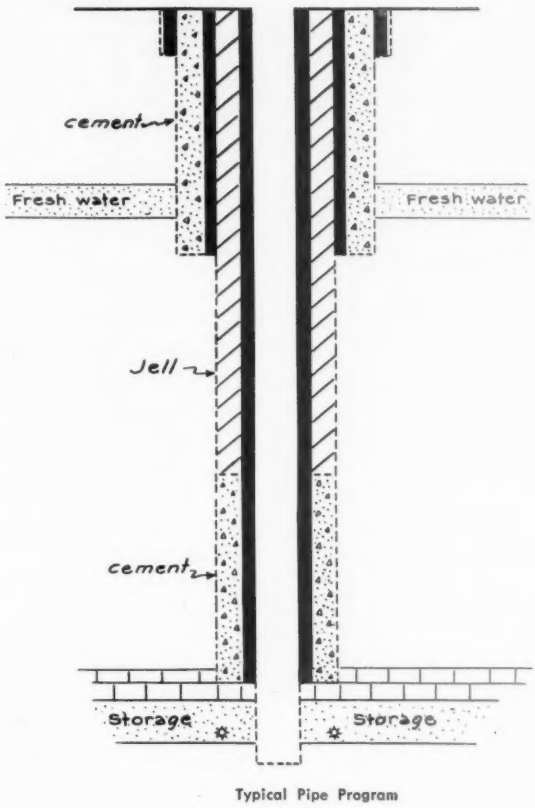
Palmer H. Montgomery is a storage engineer with United Natural Gas Company in Oil City, Pennsylvania. He joined United in 1951 after being graduated from Marietta College, Marietta, Ohio, with a BS in petroleum.



Mandrilled Jointure

Skirted Jointure

FIG. 5.



Typical Pipe Program

FIG. 6.

that the sleeve would go over the stub and a jointure could be made. This "trial sleeve" was equipped with many horizontal pins which sheared off if the sleeve went over the stub successfully. If this method was found to be unsuccessful, a "mandrel" type jointure was made.

"Mandrel jointure" consisted of running a new string of 7-in. casing and setting it inside the old 7-in. stub after the top of the stub had been swaged or mandrelled out in a manner to receive the new casing. The top of the stub was belled or mandrelled out with a guided swage slightly larger than the outside diameter of the casing. A new string of casing was then set down inside the swaged-out stub.

In either type of jointure it was frequently necessary to guide the new string so that it would line up with the stub and proper jointure could be made. This was accomplished by first setting a stone bridge or magnesium plug approximately 25 ft inside the old stub. Then with a trip spear smaller size casing or magnesium pipe was lowered into the hole and into the stub and set on the bridge.

This pipe was of sufficient length to extend above the stub to a point where the hole was normal size. The lower end of this guide was pointed and bent similar to the guide that was used in rasping operations. New casing was lowered into the hole and guided by the smaller size casing to the top of the old stub. The guide pipe was then removed with a trip spear, A caliper survey was then run to make certain that the jointure was successful. The jointure was then cemented with approximately 150 sacks of cement by the circulation method.

Fig. 5 shows two methods of joining new casing with old pipe stub left in hole.

Completion with Jointure Method. As progress was made in cleaning out inside the casing stub, considerable iron was encountered. Many types of tools were used in either drilling material up or removing it. In one particular hole, several joints of 3-in. tubing were encountered. By alternately using drill mills, ringed swages (punches) and star bits to drill material up, 250 lb of iron, ranging in size from flakes to pieces 3 in. by 4 in. were removed with the magnetic tool. Some of these short joints and larger pieces were removed with the use of such fishing tools as trip spears, bulldog spears, wall-hooks, alligator grabs, cherry pickers, and a "devil's" hand. When the cap rock was reached a magnesium or cast iron plug was set in the bottom joint and the jointure cemented.

After the jointure was cemented, well surveys were run to detect any holes or irregularities in the casing and to determine if it were set in the proper formation, and old records were examined to make certain that the casing was adequately cemented. If so, the casing was tested for leakage with 2500 psi air pressure. If the pressure test was satisfactory, the hole was completed and the combination of the new and old casing was used as a flow string.

Usually it was necessary to run smaller casing inside the old casing. After the hole was cleaned out to a point just below the old casing seat, a complete new string of 5½-in. casing was installed and cemented with 75 to 100 sacks of cement.

New Production Casing. When the following conditions existed, it was necessary to drill alongside the old production string and down to the cap rock just above the storage sand: (1) the top of the old casing stub could not be located, (2) the top of the casing stub could not be conditioned properly for jointer, or (3) the production string was 2-in. or 3-in. tubing and could not be removed. When it was necessary to drill past the old casing stub a number of problems were encountered before reaching the casing

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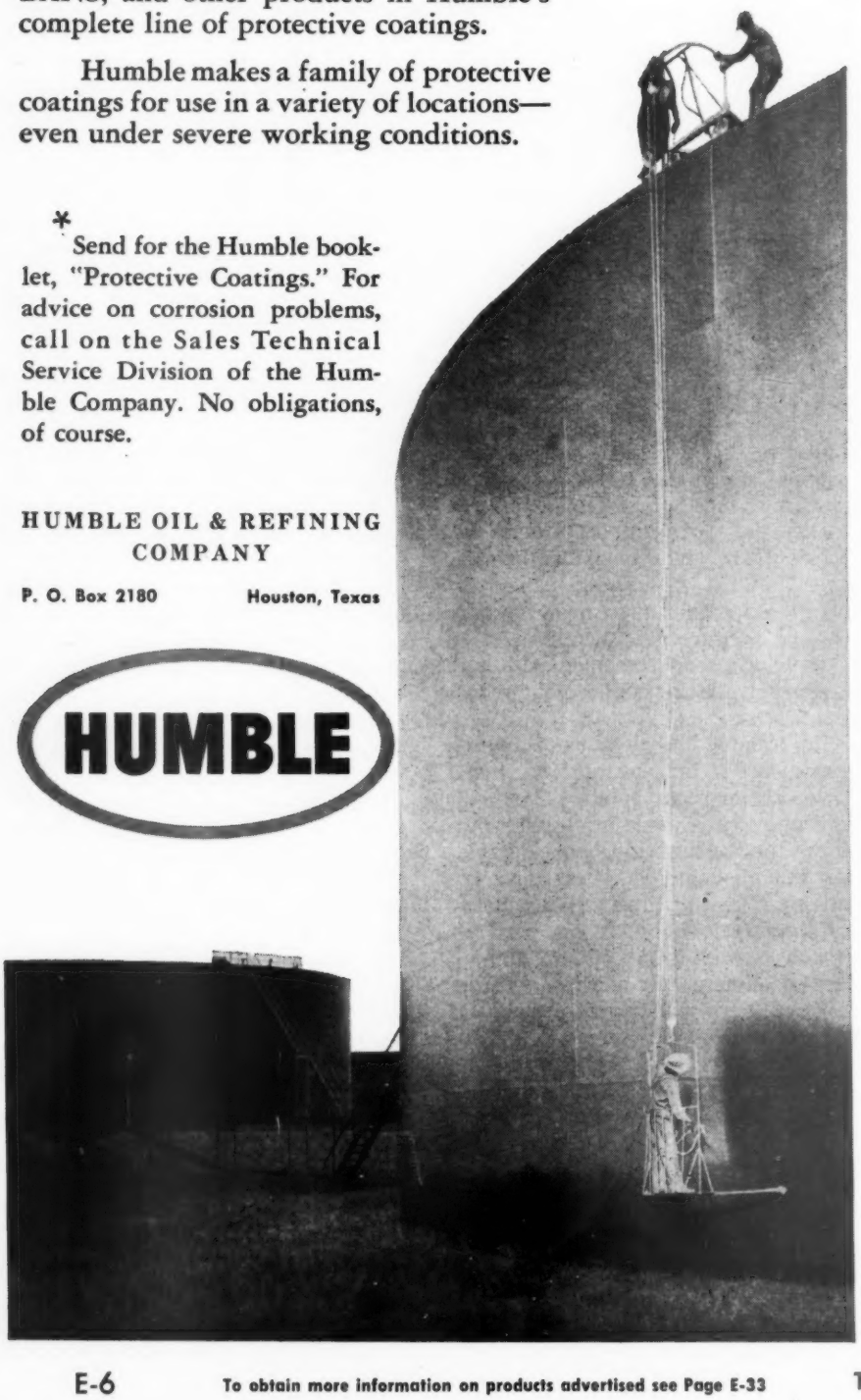


Appalachian

point. The holes not only caved considerably but tools did not work properly because of crooked holes binding against stub and foreign material left in the hole when originally drilled. Fishing jobs were frequent. Rotary methods were employed in some of these fishing operations. In one well a prong from a 3-prong grab was lost when fishing for wire line. Using a small rotary table and 3-in. tubing as rotary pipe, it was removed with an overshot.

In another well, a magnetic tool was lost when it unscrewed from the box. A sub was welded to the bottom joint of 3-in. tubing and run to the top of the magnetic tool. By rotating the tubing, the sub screwed onto the magnetic tool and was removed from the hole.

After the tools reached the casing seat, it was frequently difficult to get the production casing to follow to the proper depth. Several methods were employed to remedy the situation. The first and frequently successful method was to run the casing as far as possible, then clean out under the casing and lower the casing as cleaning out progressed. If this was not successful, the pipe was rotated with the use of the large rotary table, the power being supplied from a spudding machine. As the pipe was rotated it was lowered with the casing outfit on a standard rig. This was rigged up in such a manner that the cable tools and rotary could be run alternately.

Before running and cementing this casing, however, the open hole alongside the entire length of casing stub was gun perforated with one-half inch holes so that the old casing stub would be filled with cement as the new production casing was cemented. The number of sacks needed to cement properly the casing was calculated from a caliper survey.

The height of the top of the cement in the annular space outside the casing was found by placing radioactive cobalt in the first few sacks of cement that were run. A gamma-ray tracer survey was then run to find its location.

Testing Production String. To make certain that the casing would hold high pressure, each flow string was tested with air for leakage and blowouts before the well was completed. A cast iron plug was set in the open hole or a magnesium plug set in the bottom joint of casing and capped with approximately five gallons of gel. To insure against any possible chance of an explosive mixture during the air pressure test, the hole was purged of all natural gas. It was first loaded with 50 ft of water, then 125 lb of dry ice (CO_2) were broken into small pieces and put in the bailer. The bailer was then run to the bottom. In approximately 20 minutes all of the dry ice had sub-

limated. This purged all natural gas from the hole.

As the dry ice sublimated, the gas mixture coming from the casing was periodically checked with an explosimeter to make certain that all natural gas was removed. After purging, the well was pumped to 2500 psig with a portable 4-stage air compressor. After pressure reached 2500 psig a drop pressure test was taken for 24 hours.

RE-PLUGGING

Sometimes it was necessary to re-plug abandoned holes for one of several reasons such as (1) if the original production casing was in bad condition and too small to run a new casing inside, (2) if tools or other objects left in the bottom of the hole could not be removed.

When a well had to be re-plugged, the following general method was followed:

1. A complete hole caliper survey was run to determine volumes of cement and heavy mud needed.
2. Casing left in the hole that could not be recovered, was perforated from top to bottom.
3. The face of the storage sand was cemented and a cast iron plug set directly above the cement in the cap rock.
4. Tubing was run to the top of the plug and the bottom 500 ft of hole was cemented through it.
5. The tubing was pulled above the top of the cement and a heavy mud-gel mixture pumped through it, filling the hole to about 700 ft of the top.
6. The tubing was pulled above the top of heavy mud-gel mixture, and hole cemented to surface.

CONDITIONING ACTIVE WELLS

To condition wells which were still producing, small spudding machines were generally used. After the hole was cleaned out to its original depth, a caliper survey was run to detect any holes in the casing and to locate the bottom of the production string. A gamma-ray survey was also run to find depth and thickness of formations.

Some of these wells were drilled when the rock pressure of the producing pool had dropped considerably below the original rock pressure and therefore the original cement job might not be satisfactory for high pressure storage operations. Since the expected operating pressures of this pool were planned to be as high as 2200 psi, many of these producing strings were re-cemented.

In this re-cementing, a magnesium or cast iron plug was set in or below the bottom joint of production casing. The casing was perforated at the top of the original cement at which point a squeeze cement job was applied.

After drilling out with cement the hole was completed to the Oriskany sand; casing was washed with white gasoline and the sand treated with acid which removed a considerable amount of characteristic gummy residue. Several of the wells were lightly shot.

DRILLING NEW WELLS

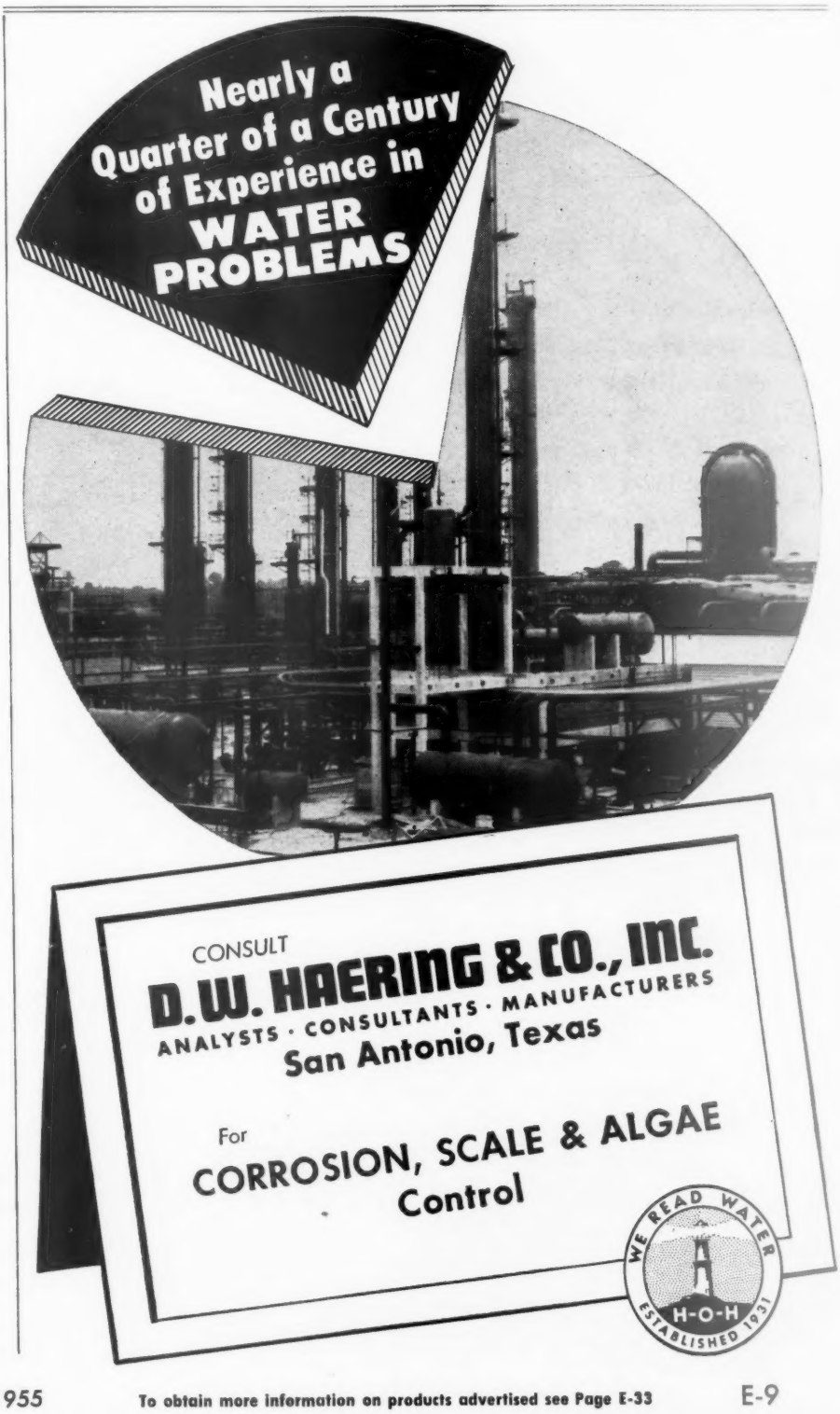
After the reclamation of 15 abandoned holes, plugging of 4, and conditioning of 16 active wells, 21 new wells were drilled in this project. No unusual problems were encountered in accomplishing this. After installing and cementing the production casing in each new well, it was tested with air to 2500 psi prior to drilling-in operations.

In drilling in, special care was exercised to avoid the hazard of getting so large an open flow as to blow the tools out of the hole.

The use of lubricating equipment and loading the hole with fluid were resorted to, in some instances, when exceptionally large wells were anticipated.

Fig. 6 shows the pipe program of a typical (Oriskany) storage well.

ACKNOWLEDGMENT—The author wishes to thank United Natural Gas Company, Oil City, Pennsylvania, for permission to publish the information contained herein, and is grateful to John A. Comet for constructive criticism.



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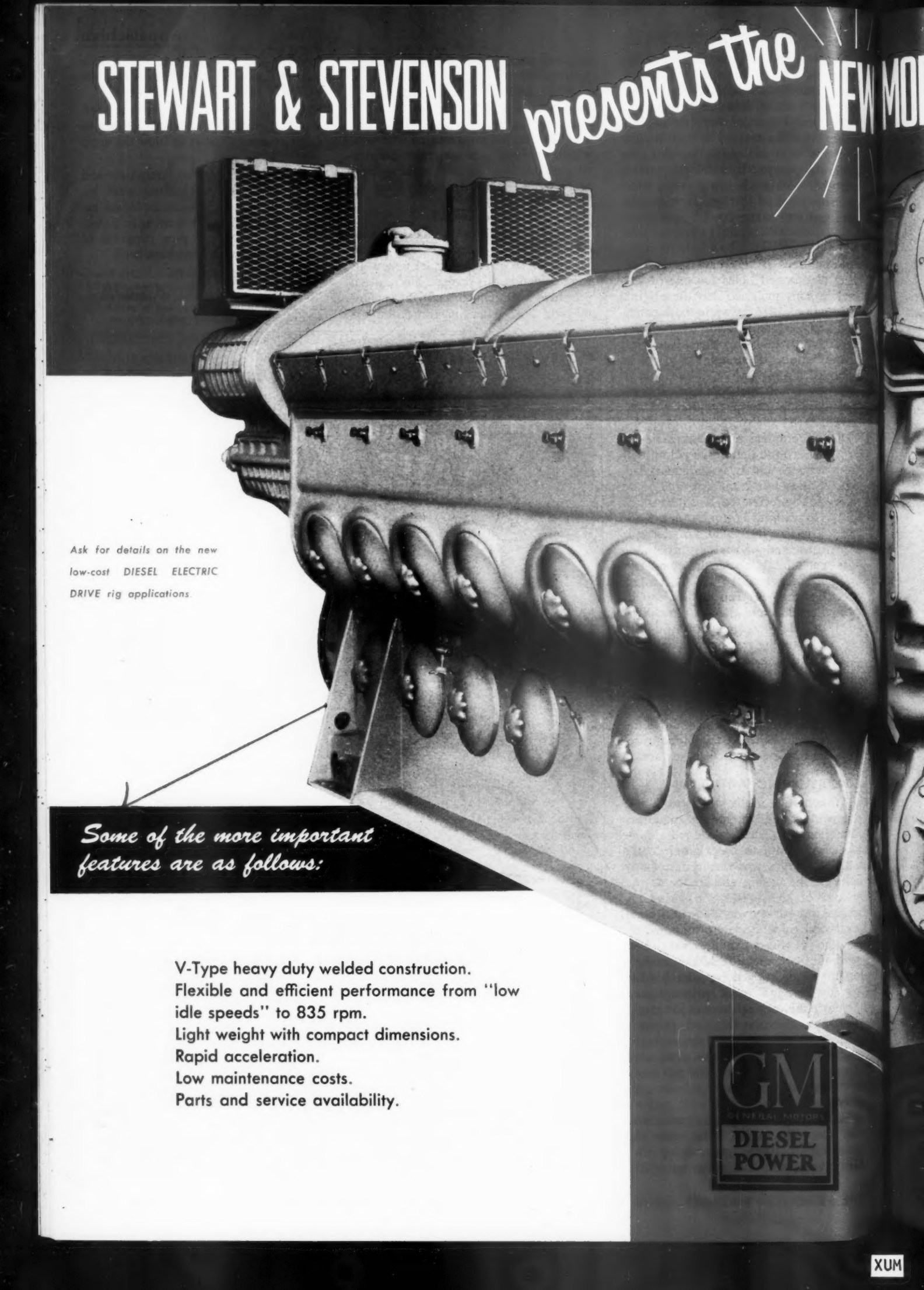

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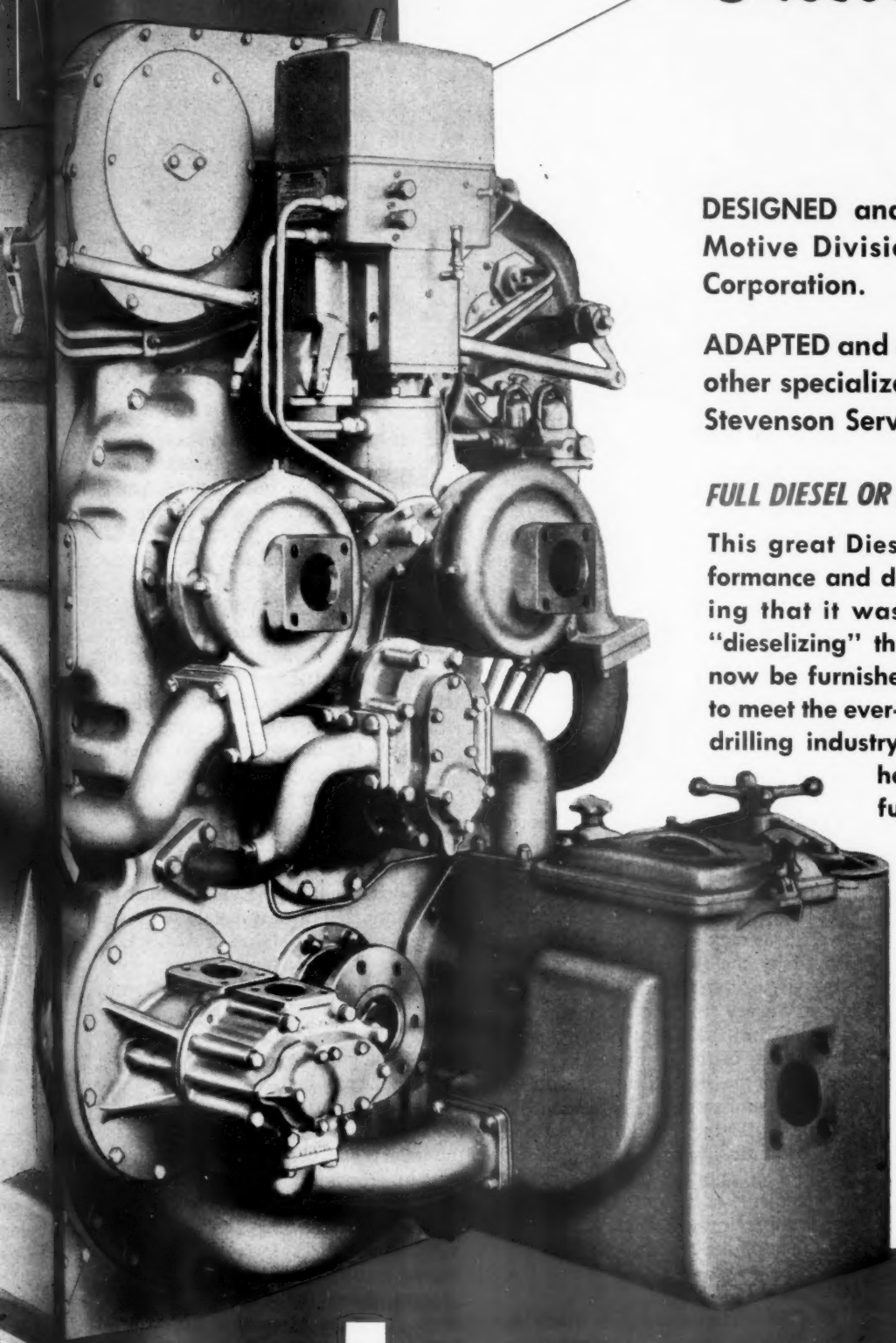

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- Submerged Lands Act purportedly divided State and Federal jurisdiction; adjoining states control marginal seas and Federal government controls outer Continental Shelf.
- Outer Shelf Act set up regulations for leasing and mining operations on Continental Shelf under Federal control.
- Legal problems of leasing, exploring, and drilling in both "tidelands" and outer shelf are working out.
- Greatest obstacle, however, is inability to define boundary line on the sea and seabed between State and Federal dominion.
- Outer Shelf lies outside territorial limits of United States which could provide controversy in international circles.

HOW TO LEASE TIDELANDS

Lucius M. Lamar

BOTH the Submerged Lands Act and the Outer Shelf Act (passed in 1953) provided for the validation of State leases in force and effect on June 5, 1950; subject to certain conditions, including the payment of rentals and royalties not theretofore paid. In general, the requirements of validation were not difficult to meet; but some Gordian problems, involving large sums of money, were encountered in connection with split leases, that is, those lying partly in State and partly in Federal territory; and in connection with leases in areas where the location of the dividing line was uncertain.

As to leases lying in the State area, the lessee was, of course, free to commence or resume drilling and producing activities in accordance with the terms of his State lease and the laws of the State. The State, in turn, was free to issue new leases.

As to leases lying in the outer continental shelf, the Outer Shelf Act provides that the lease shall continue in effect in accordance with its original terms as to area, term, minerals covered, rentals, and royalties, but that the Secretary can "write in" additional provisions in the form of regulations; and that the lessee must pay an additional royalty-equivalent to the State severance tax in effect on the date of the Act. The regulations, as finally promulgated, are incorporated as a part of validated State leases. Prior to the issuance of the regulations, the Secretary permitted the development and operation of validated leases by the issuance of individual permits.

The Outer Shelf Act, Section 11, authorizes geological and geophysical exploration in the outer continental shelf. State laws in Louisiana and Texas also authorize such exploration in their waters. The Secretary of the Interior has entered into what he calls "cooperative agreements" with the Commissioner of the General Land Office of Texas and with the Louisiana Wild Life and Fisheries Commission to establish what amounts to a joint system of regulation. In Louisiana, for instance, any person desiring to conduct geological and geophysical exploration in the outer continental shelf must first secure a permit from the Louisiana Wild Life and Fisheries Commission.

Thereupon he is authorized to go ahead upon condition (1) that such operations will be confined to such area or areas as may be designated and approved by the Regional Oil and Gas Supervisor of the United States Geological Survey; (2) that he obtain permission from the Corps of Engineers, Department of the Army; and (3) that he file with the Supervisor and with the State Commission an agreement to comply with the regulations of the State Commission which are adopted as the regulations of the Secretary. Enforcement is delegated to the regional supervisor who may accept the assistance of the State.

LOUISIANA

The Louisiana regulations, which became effective July 15, 1954, were promulgated after extensive conferences between State officials, Federal officials, and oil industry representatives. They are, on the whole, reasonable and appropriate, though some appear to go beyond the stated purpose of protecting and conserving aquatic life. Most of the rules which may possibly be *ultra vires* seem to be intended to promote safety or to enable the Commission to keep track of what is going on.

The area affected by the Outer Shelf Act lies outside the State of Louisiana. Within that area, the United States asserts exclusive jurisdiction and control and repudiates any interest in or jurisdiction on behalf of any state for any purpose. It can be seriously questioned whether the State Commission has any power to make regulations affecting the outer shelf and whether the Commission's agents can exercise any authority in that area.

The question, however, seems to be academic—there seems to be no reason why the Secretary of the Interior cannot adopt such regulations as his own even though not issued validly by the State Commission. In other words, they become valid when adopted even though they were not valid to start with. By the same token, they can be enforced by the regional supervisor of the Geological Survey to whom enforcement can be delegated.

The regulatory scheme outlined above has some advantages. The boundary line between State and Federal jurisdiction off the coast of Louisiana is in dispute. If the operator secures permission from the State Commission, from the Supervisor of the Geological Survey, from the Corps of Engineers, from the Coast Guard and from the State Mineral Board (which has exclusive authority to issue prospecting permits in State waters)—he can cruise and explore in any offshore water area without worrying about who owns the bottoms.

Although the Outer Shelf Act provides for the issuance of new leases by the Secretary of the Interior, two pre-

Condensed from lecture by Lucius M. Lamar, Vice President and General Counsel, The California Company, before the Southwestern Legal Foundation, sponsored by Southern Methodist University, Dallas, Texas, January 19-21, 1955.

liminary steps were essential: The establishment of a survey system and the issuance of leasing and operating regulations.

Both Louisiana and Texas had previously adopted a network of surveys in the Gulf of Mexico tied in to established landmarks on dry land and extended seaward by a system of coordinates. Wisely, in my opinion, the Secretary adopted the existing State systems; extending the network to an average water depth of about 120 ft, the maximum in which drilling operations can be conducted by present methods. As those methods are improved, the network can be further extended. Leasing maps showing these surveys were published by the Secretary in the summer of 1954 in a convenient and inexpensive form, and were given wide circulation.

REGULATIONS

The leasing and operating regulations were released May 10, 1954 after a series of conferences between representatives of industry and of the Interior Department. The leasing and unitization regulations, together with approved lease forms, are found in Title 43 Part 201 and are administered by the Bureau of Land Management. The operating regulations, including those for prevention of waste, control of operations, measurement of production, and forms and reports, appear in Title 30 Part 250 and are to be administered by the Director of the Geological Survey.

These regulations show the good effects of careful preparation and represent a reasonable compromise between the viewpoint of the Department and that of the operators. In the preparatory conferences the Department seemed to feel that it should regulate or be in a position to regulate all drilling and producing operations at all stages of their progress. The industry representatives seemed to feel that a minimum of regulation was required, because the great cost and hazard of offshore operations automatically insure the most efficient and unwasteful operating procedures. The operating regulations are authorized by Section 5 of the Act which empowers the Secretary to issue regulations for the prevention of waste and conservation of the natural resources of the outer continental shelf, the protection of correlative rights therein, and for several other purposes.

BIDDING

Basic lease requirements are found in Section 8 of the Outer Shelf Act. Oil and gas leases can be granted to the highest responsible qualified bidder by competitive bidding. Neither the Act nor the regulations define the terms "qualified" and "responsible." Bidding is by sealed bid. At the discretion of the Secretary, either the royalty is fixed and bidding is on a cash basis; or the bonus is fixed and bidding is on a royalty basis. In either case the minimum royalty is 12½ per cent. Sulfur leases are issued separately; the minimum royalty is 5 per cent and the highest cash bonus wins. Other minerals can also be leased separately. Under the law it is possible that leases covering different minerals on the same land can be issued to different lessees.

LEGAL SYSTEM

Section 4 of the Outer Shelf Act is something of a legal curiosity, purporting to establish a complete system of law for the subsoil and seabed of the outer continental shelf and artificial islands and fixed structures thereon. Apparently the waters above are left to the devices of international law.

The Constitution and laws and civil and political jurisdiction of the United States have first place in the scheme "to the same extent as if the outer continental shelf were an area of exclusive jurisdiction located within the state." Next come "the civil and criminal laws

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of each adjacent state as of the effective date of the Act" which, subject to the system of Federal law, are declared to be the law of the United States, to be administered and enforced by the appropriate officers and courts of the United States. State taxation laws are not included. The President is empowered to extend dividing lines between states, which he has not yet done.

The Longshoremen's and Harbor Workers' Compensation Act and the National Labor Relations Act are expressly declared applicable. The authority of the Coast Guard and of the Secretary of the Army are expressly affirmed.

Since the entire outer continental shelf lies outside of the territorial limits of the United States, the system of law established by Section 4 seems likely to provide for international lawyers a field-day of speculation and controversy. I regret that I am not qualified to join in the fracas. I know only enough about international law to describe it as consisting of accepted customs which are mutually convenient; of treaties which you do not care to repudiate; and of what you can get away with. Our occupation of the continental shelf seems to fall in the category last mentioned.

There are a number of difficult questions concerning the boundaries of the areas covered by the Submerged Lands Act and the Outer Shelf Act, respectively. The Submerged Lands Act is dominant, since the outer boundary of the area covered by that Act is the inner boundary of the area covered by the Outer Shelf Act.

The area covered by the Submerged Lands Act is described in Section 2, sub-sections (a), (b), and (c). The Act covers submerged lands beneath non-tidal waters, with which we are not here concerned. The starting point for measuring the area covered by tidal waters is the coast line, which is defined in the Act as the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters. This is almost exactly the language used to describe the landward line of the area sued for in the California, Texas, and Louisiana cases, and covered by the decrees handed down in those cases.

The definition is short and the words are simple, but the appearance of simplicity is deceptive. Even the line of ordinary low water must be measured over a cycle of 19 years to secure an average of tidal variations; a measurement which could be complicated by erosion of or accretion to the coast during the process of measurement. There are no established and accepted judicial criteria by which inland waters can be identified.

For present purposes, we shall assume that the coast line is one which can be determined and located. This assumption was indulged when a number of oil companies joined in making an aerial survey of the coast lines of Texas and Louisiana about a year ago. Copies of the survey material were presented to State and Federal officials with the idea that a common factual background would be helpful, even though legal disputes seem inevitable.

Starting with the coast line, the Submerged Lands Act grants to all coastal states a minimum belt of submerged lands having a width of three nautical miles. In the Atlantic and Pacific Oceans, the minimum is also the maximum. These states get exactly three geographical miles, regardless of circumstances. In the Gulf of Mexico the Congress was somewhat more generous. Each Gulf state is granted an area extending to the boundary line of such state where, in any case, such boundary as it existed at the time such state became a member of the Union or as heretofore approved by Congress, extends into the Gulf of Mexico beyond three geographical miles. There is, however, a maximum limit in the Gulf also. No Gulf state, regardless of

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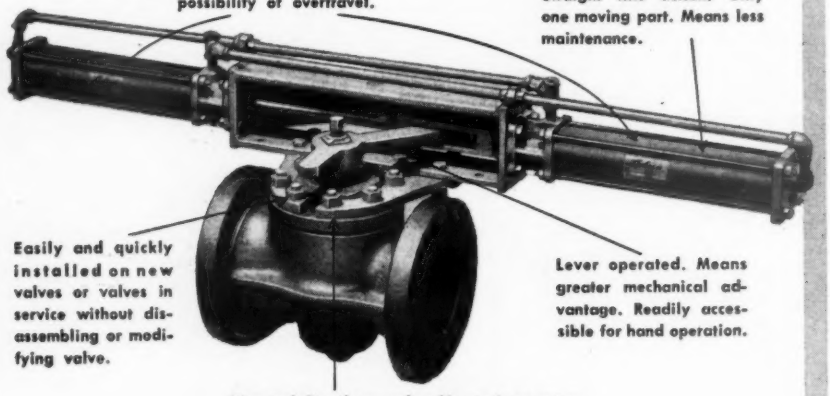
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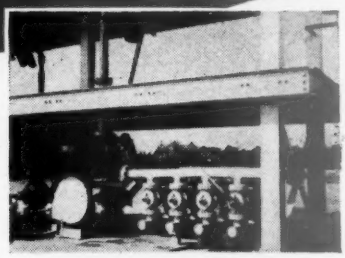
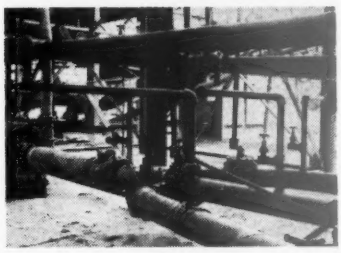
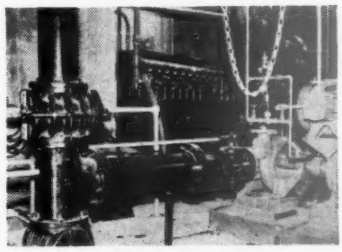


On Petroleum Applications



In Chemical Plants



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its boundaries, can acquire through the Submerged Lands Act a belt of submerged lands extending into the Gulf of Mexico more than three marine leagues, or nine nautical miles.

TITLE?

At this point it is pertinent to consider the essential nature of the Submerged Lands Act. At the time of its passage the Supreme Court of the United States had declared in three successive opinions that the states had no title to anything lying seaward of the coast line, but that the United States had paramount rights and dominion over all such lands. The Court declined to hold that title was in the United States. This is not the place to inquire into the nature of paramount rights and dominion; nor as to what happened to the title that was taken away from the states but not accorded to the Federal Government. The point is that the states had nothing left seaward of the coast line. Accordingly, what the states got from the United States by means of the Submerged Lands Act was a gift or gratuity, the terms and conditions of which were dependent entirely upon the wishes of the donor and over which the donee states had no control whatsoever.

Under the terms of the Submerged Lands Act only two kinds of boundary are of any significance. First, the boundary as it existed when the state became a member of the Union; and second, a boundary approved by Congress before May 22, 1953. Any state boundary not falling in one of these two categories simply does not exist, as far as the Submerged Lands Act is concerned.

In Louisiana, especially, there are practical obstacles to further leasing and development, because of the conflicting three-mile and three-league historical claims, and because of the difficulty of defining the seaward limit of inland waters in certain areas, such as Atchafalaya Bay. I doubt that boundary questions can be settled by unilateral action by any state government or by the federal government, because such action by either party might take something away from the other party; which cannot be done without the other party's consent.

COMPROMISE?

Negotiation between state and federal officials has been considered, and in the case of Louisiana has been attempted. I feel that this approach is not fruitful. No federal official is authorized by law to make an agreement binding on the United States. No Louisiana official is empowered to bind the State of Louisiana; or, I believe, are the officials of other Gulf states so empowered. Accordingly any agreement between state and federal officials would have to be approved both by the Congress of the United States and by the State Legislature. It is the prevailing opinion that such approvals could not be secured.

OR COURTS?

The only remaining recourse is the courts. For Constitutional reasons, any such litigation would have to be instituted by the federal government. If conducted as the California case was, such litigation, whether tried piecemeal or blunderbuss style, would be intolerably tedious and prolonged. There is, however, one approach which could greatly minimize the difficulties. If in a suit, say between the United States and the State of Louisiana, the opposing Attorneys General could stipulate the location of the "coast line" (the most difficult part of the problem); and if such stipulation were acceptable to the court, the remaining issues are relatively simple: *e.g.* does Louisiana have a three-mile boundary or a three-league boundary? And by what method is such boundary to be derived from the stipulated coast line? I suggest that this approach be given serious consideration both by State and Federal governments. * * *

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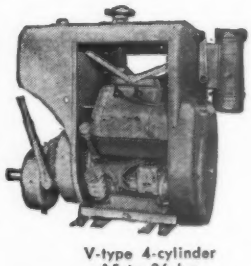

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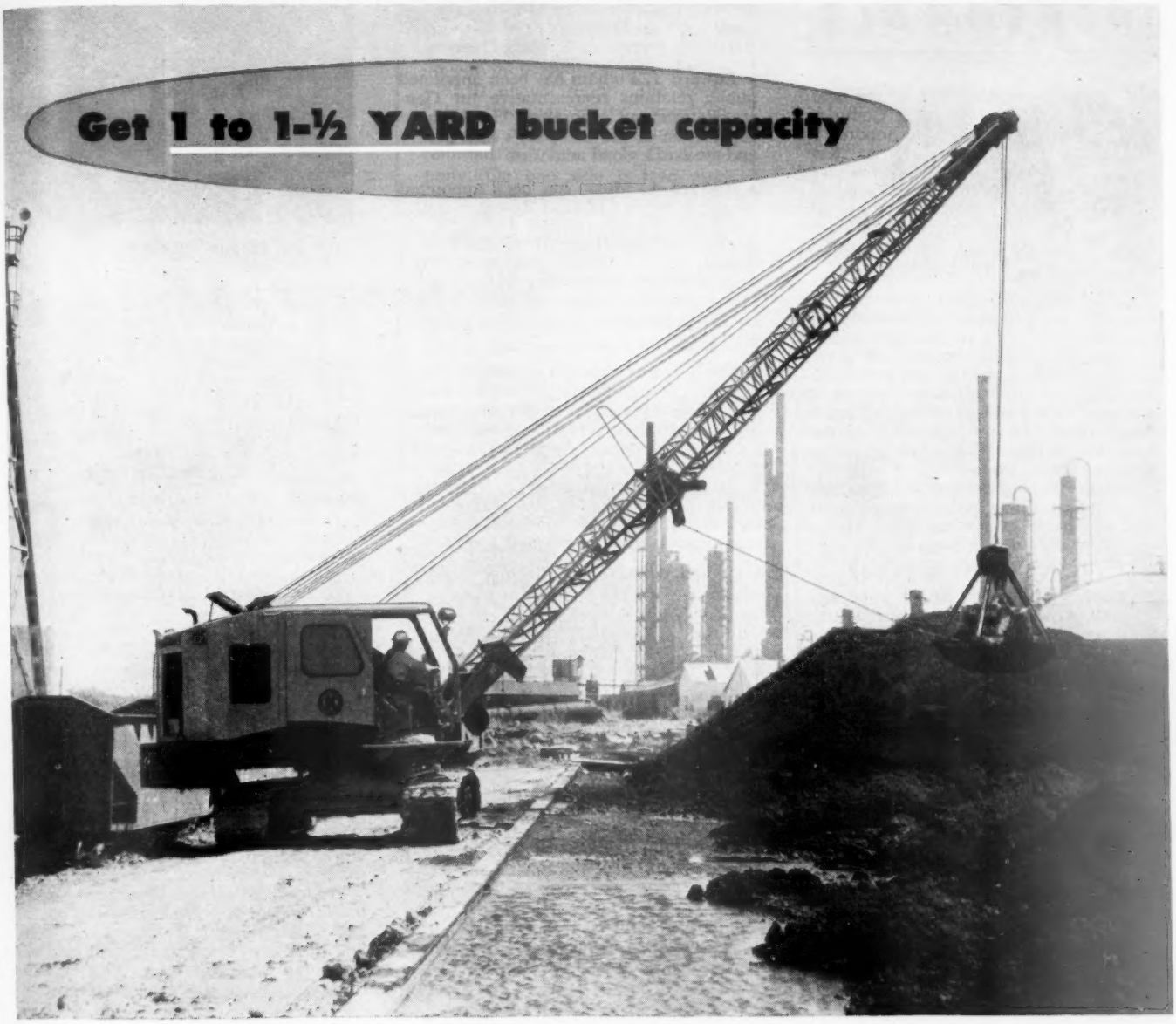

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PERSONALS

Paul G. Blazer, chairman of the board of Ashland Oil and Refining Company, Ashland, Kentucky, has been honored by the Kentucky Press Association as "Kentuckian of the Year." The award is given annually to a citizen for services rendered to the state. Blazer founded the Ashland Refining Company which was later merged with the Swiss Oil Company to form Ashland Oil and Refining.

Ford, Bacon & Davis, Inc., has announced that **Charles C. Whittelsey** has been advanced to the position of executive vice president, having formerly been vice president in charge of the firm's construction activities. He will also continue as executive vice president of the firm's subsidiary, Ford, Bacon & Davis Construction Corporation, with headquarters at Monroe, Louisiana.

William B. Poor became vice president and manager of the construction department of Ford, Bacon & Davis, Inc. He has also been elected a director of the firm, and of the Construction Corporation.

The directors of the British American Oil Company Limited announce the resignation of **Ole Berg, Jr.,** as president and director, and the appointment of **Milton S. Beringer** as president and chairman of the board, and **J. Gerald Godsoe** as executive vice president. Beringer has been chairman of the board and director, and Godsoe vice president and director.

E. D. Brockett, Jr., has been elected a vice president of Gulf Oil Corporation. He will be manager of the company's Houston, Texas, production division, succeeding Vice President **B. C. Belt** who has announced his intention to retire shortly. The company's Houston Production division embraces operations in East Texas and the Gulf Coast region of that state, Louisiana, Arkansas, Mississippi, Alabama, Georgia, and Florida. Brockett, who joined Gulf in 1934, will be at production division offices in Houston.

James P. Patterson, retired vice president in charge of marine operations of the American Oil Company, has been appointed chairman of the Tanker Requirements Committee of the Maritime Administration, U.S. Department of Commerce. Patterson succeeded **William Dunning.**

Edward T. Fulham has been appointed public relations representative for General Petroleum Corporation. He will have supervision of the company's film library and speaker's panel activities.

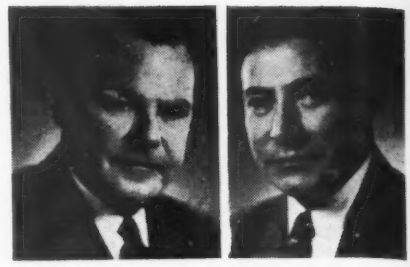
Richard A. Morse has been appointed associate director of Gulf Research & Development Company. He will have administrative direction of research concerned with drilling, production, and transportation. For the past six years, Morse has been connected with the Research Department of Stanolind Oil and Gas Company.

The board of directors of Middle States Petroleum Corporation has elected **Philip C. Dixon** as president of the corporation, to succeed the late **Joseph Glass.** Dixon, a petroleum engineer, had been vice president since 1949. The board of directors of Midstates Oil Corporation, operating subsidiary of the Middle States Petroleum Corporation, also elected Dixon president and director.

Oil Industry Information Committee chairmen for 1955 announced by American Petroleum Institute are: **W. R. Huber,** Gulf Oil, chairman; and **L. R. Kamperman,** Leonard Refineries, Inc.; **Kerryn King,** The Texas Company, **Richard Rollins,** Atlantic Refining; **J. H. Sambower,** Shell; and **Roy M. Stephens,** Humble, vice chairmen.

George R. Bryant, vice president of The Texas Company for the past four years, has resigned his position to become president of Jefferson Chemical Company, Inc., owned jointly by American Cyanamid Company and The Texas Company. Bryant succeeded **P. M. Dinkins,** who has served as president of Jefferson Chemical since 1946.

James N. Gorringe, formerly coordinator of executive development for the company, has been named employee relations manager for Esso Standard Oil Company. Gorringe, who has headed employee relations at the company's Baltimore, Bayway and Bayonne refineries has also served as assistant process superintendent of the Bayonne refinery.



H. M. Russell E. L. Steiniger

Edward L. Steiniger was elected vice president of Sinclair Oil Corporation in charge of the foreign exploration and production program, which includes operations in Venezuela, Ethiopia, and Italian Somaliland. Since 1950 Steiniger had been president of Venezuelan Petroleum Company, in which Sinclair holds an 86½ per cent interest. **Hugh M. Russell** will succeed Steiniger as president of Venezuelan Petroleum. Russell was vice president from 1942 to 1952.

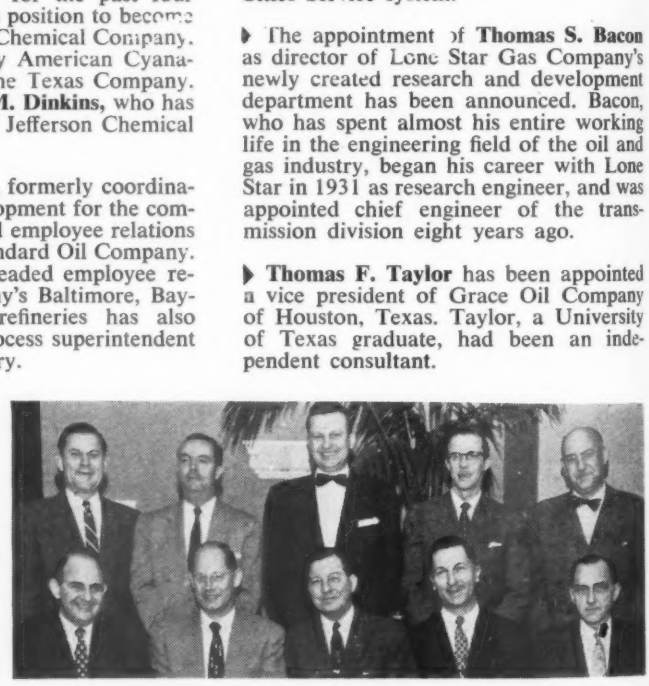
F. A. Bush, chief geologist for Sinclair Oil and Gas Company, while retaining his present duties, is transferring his headquarters from Tulsa to New York, to succeed Russell as assistant to the chairman.

The election of two new members of the board of directors of Cities Service Company has been announced. New members are **A. P. Frame,** in charge of manufacturing, research and petrochemical development, and **Charles S. Mitchell,** in charge of transportation facilities of the Cities Service system.

The appointment of **Thomas S. Bacon** as director of Lone Star Gas Company's newly created research and development department has been announced. Bacon, who has spent almost his entire working life in the engineering field of the oil and gas industry, began his career with Lone Star in 1931 as research engineer, and was appointed chief engineer of the transmission division eight years ago.

Thomas F. Taylor has been appointed a vice president of Grace Oil Company of Houston, Texas. Taylor, a University of Texas graduate, had been an independent consultant.

New York Chapter of Nomads has elected officers for 1955. Seated, left to right, are Maurice F. Delano, R. S. Stokvis & Sons, Inc., secretary; Herb E. Maland, R. J. Eiche & Associates, Inc., vice president; Stewart D. Beckley, Beckley, Haltom & Hickman, president; Douglas L. Grill, Link-Belt Company, treasurer; and E. E. Andreason, W-K-M Manufacturing Company, Inc., sergeant-at-arms. Standing are Russ V. McIntire, Baker Oil Tools, Inc., regent; David C. Washburn, Cameron Iron Works, Inc., secretary; Don E. Kircher, Gardner-Denver Company, sergeant-at-arms; William E. Volkman, Cardwell Manufacturing Company, Inc., assistant treasurer; and Norris L. Boulden, Jr., International General Electric Company, Inc., regent.



The Los Angeles Chapter of Nomads' old and new officers, left to right, (seated) are Ox Morgan, Falcon Products, Inc., sergeant-at-arms 1954; John Flanagan, Johnston Testers, Inc., president 1954 and regent 1955; Joe Schlarb, Chiksan Company, vice president 1954 and president 1955; Leo Cypher, Baash-Ross Tool Company, treasurer both years; Knight Templeton, S. R. Bowen Company, assistant secretary 1955; (standing) Harry Taylor, Bettis Rubber, assistant treasurer 1955; Harry Hester, McCullough Tool, secretary 1954 and vice president 1955; Bob Gaylord, Wagner-Morehouse, sergeant-at-arms 1955; Pop Atkins, Emsco, secretary 1955. Not shown, Rex Collins, Hydril, deputy sergeant-at-arms 1955; and Jim Hughes, Lane-Wells, regent both years.

Members of the technical subcommittee of The National Petroleum Council's Committee on Petroleum Imports have been named by **Jake L. Hamon,** General Chairman.

Richard J. Gonzalez, Humble, is chairman. Other members are **Kenneth E. Beall,** Phillips Petroleum Company; **James V. Brown,** National Petroleum Council; **Austin Cadle,** Standard Oil of California; **Paul D. Williams,** Western Refiners Association; **Stark Fox,** Oil Producers Agency of California; **Minor S. Jameson, Jr.,** Independent Petroleum Association of America; **E. Madison,** The Texas Company; **Albert J. McIntosh,** Socony-Vacuum Oil Company; **Serge B. Jurenev,** Continental Oil Company; **W. G. Moore,** Gulf Oil Corporation; **C. F. Parker,** Union Oil of California; **Cecil L. Burill,** Standard Oil of New Jersey; **W. L. Leavitt,** Standard Oil Company of Indiana; **H. N. F. Schwall,** Shell Oil Company, Inc., **N. G. Dumbros,** Ohio Oil Company; **C. V. Horky,** Pure Oil Company; and **Fred Van Covern,** API.

The appointment of **J. E. Hughes,** Q.C., as general counsel and secretary of Shell Oil Company of Canada, Ltd., has been announced. He was created a Queen's Counsel in 1952 and joined Shell in the same year as its general solicitor.

J. A. Ross, Jr., C.A., has returned to his position as controller of Shell. Appointed controller in 1945, Ross has spent the last two years in the United Kingdom and the United States on special assignments for Shell.

Buddy Brothers, former head coach of the University of Tulsa football team, has been named assistant to the president of Tuloma Builders, Inc., Tulsa. Brothers will handle Tuloma's public relations, safety program and employees' trust fund. Tuloma, formerly part of Midwestern Constructors, Inc., was formed last August and specializes in engineering and construction of gasoline, industrial and chemical plants, gas compressor and oil pump stations and waterflood units.

J. Kay Lindsay has assumed duties as FPC's director of administration, a newly-created position. Lindsay will be responsible for the coordination of all of the FPC's administrative services, including personnel matters, budget and fiscal affairs, and "housekeeping" activities. He has been chief of the District of Columbia government's employment and training division since 1952.

Roy E. Jones has been elected president and director of North Shore Gas Company, Waukegan, Illinois. Jones returned as vice president last September after serving as executive vice president of People's Water and Gas Company in North Miami, Florida, for three years. He was formerly with North Shore Gas.

Oscar F. Rogers has been named superintendent of production and engineering for North Shore. Rogers became assistant to the chief chemist in the coke plant division of North Shore in 1928 and was made chief chemist in 1935. In 1947 when the company converted to natural gas operation he was promoted to engineer and chief dispatcher.

John W. Proctor, of Edmonton, has been appointed executive secretary of the Alberta division, Canadian Petroleum Association, and will make his headquarters in Calgary. For the past four years Proctor was general manager of the Alberta Interfield Gas Lines Limited. He took a general engineering course at the Royal Military College.

IDEA!

White Eagle Oil Company came up with an innovation in connection with its annual report. The stockholder receives in the report, a stamped, addressed postcard to be returned to White Eagle Oil Company. On one side a form was printed on which the stockholder was asked to check his impression of each section of the report, indicating whether it had enough detail, was useful and clearly presented, and if the stockholder thought it could be improved. Response to the inquiry has been excellent, the company says.

Annual reports are the key communication between companies and stockholders. Anything that will improve them is a valuable addition.

S. P. Osborn has been elected assistant comptroller of Texas Eastern Transmission Corporation. Osborn joined Texas Eastern in January, 1948, and has served the company as chief accountant from that time until the present. Prior to coming with Texas Eastern, he was assistant treasurer for Columbia Gas System Companies.

Frederick L. Ehrman, of New York City, has been elected chairman of board of Monterey Oil Company, succeeding **Lowell Stanley.** Ehrman is a partner in the investment banking firm of Lehman Brothers and has been a director and member of the executive committee since the company was organized in 1950. Stanley will continue on the board.

Roy C. Stringfellow has been appointed manager of Magcobar's Shreveport, Louisiana, division. An employee of Magcobar since May, 1949, Stringfellow began as a field service engineer.

James R. Homan has been recently named California division sales manager for Magcobar. Homan was formerly a Magcobar sales representative in Oklahoma City following extensive experience in drilling activities in the Middle East.

Pleas O. Hardwick, Shreveport, Louisiana, has announced the association of **Miss Natalie Forte** as petroleum market analyst and office manager.

E. W. Berlin

Standard-Vacuum Oil Company has announced the appointment of **E. W. Berlin** as the company's general representative for its operating subsidiaries in Indonesia. Stationed at Djakarta, he will have administrative supervision over Stanvac's exploration, producing refining, marine, and pipe line transportation and sales activities in the Indonesian republic. He succeeded **G. L. McCoy** who, after a tour of Stanvac operating areas in Indo-China, Malaya, Thailand, and other Far East countries, will return to the company's New York headquarters for reassignment.

Richfield Oil Corporation has announced the appointment of **Fred B. Behrens** as staff assistant to **David E. Day,** vice president and manager of the manufacturing and pipe line department. Behrens, formerly vice president of Wilshire Oil Company, Inc., will have special assignments on supply and distribution of crude oil and refined products. He is a graduate of the University of Wisconsin.

Three financial and administrative officers have been advanced by Tide Water Associated Oil Company. **Richard A. Ny,** formerly western division treasurer, was elected assistant treasurer.

Edward H. Hermsen, an attorney who joined Tide Water's western legal staff in 1945, was elected assistant secretary. **Wilbur R. Manion** was elected as assistant treasurer, in charge of the western division treasury department. Joining the company 26 years ago as an office boy, he rose through the Tide Water accounting organization to become western division paymaster.

L. W. Leath and **W. M. Flowers** have been elected directors of Sinclair Refining Company. Leath is vice president and general sales manager of the refining company, and Flowers is president of Sinclair Research Laboratories, Inc.

At MIT Regional Conference in Dallas were: Dr. Robert E. Wilson, chairman of the board, Standard Oil Company (Indiana); E. O. Vetter, assistant vice president, Geophysical Service, Inc., and chairman of the conference; Dr. James B. Killian, president, Massachusetts Institute of Technology. The conference on "Frontiers in Science and Engineering" was sponsored by MIT alumni clubs in southwestern United States and Mexico. Dr. Dayton H. Clewell, Magnolia, president of the host club in Dallas, Texas, welcomed the 300 who attended.

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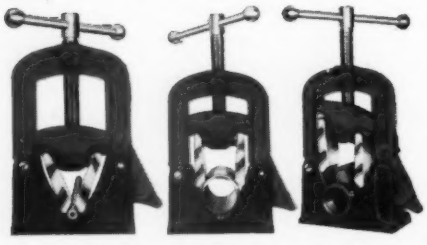

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DEATHS

Halvern N. Norris, who was prominently identified with the discovery of oil in the Cuyama Valley in California died recently at Ventura, California.

George C. Williams, noted petroleum geologist, died recently in Los Angeles, California.

Roy E. Dow, assistant to the general manager of sales of the Bethlehem Supply Company, died recently. He had been associated with the oil industry for almost four decades, having worked for Bethlehem Supply Company and its predecessor, the International Supply Company, for 37 years. Death came unexpectedly after a two-months illness.

George C. Sproule, retired oilman, died recently. Sproule had been associated with the Kern Oil Company since 1921 and retired as its superintendent in 1945.

Charles A. Son, civic leader, early day-oilman and manager of Governor Goodwin Knight's campaign, died recently. At the turn of the century, Son entered the oil business through the Midway-Sunset field in Kern County. At the time of his death he controlled interests in many leases in this area.

Raymond Godet, pioneer of European exploration and drilling, died in Paris, France, January 24. Godet built one of the largest French refineries, at Berre, serving as general manager until 1940. Also he founded Forex, a drilling and exploration company in 1940. He was president of the firm, the only drilling contractors in France during the 15 years since the company was founded, until his death.

V. E. Elkholm, organizer of the Viking Oil Company, died recently at his home in Abilene, Texas. Elkholm also organized the Man-Tan Chemical Company.

Phillip A. Wilner, manager of the Detroit district office of Instruments, Inc., was killed in an automobile accident in downtown Detroit, Michigan. Joining Consolidated in June, 1953, as a sales engineer in the firm's Pasadena, California, headquarters, Wilner was named resident field engineer in charge of Detroit district operations in 1954. An electrical engineering graduate of New York University and holder of a master of science degree from the University of Iowa, he was promoted to manager of the Detroit district office in October, 1954.

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THE PETROLEUM ENGINEER

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Dr. George M. Lees, M.C., D.F.C., F.R.S., who was for nearly 23 years chief geologist to The British Petroleum Company (previously Anglo-Iranian Oil Company) before his retirement in 1953, died in London January 25. He joined British Petroleum as an assistant geologist in 1921 and spent a number of years in the Middle East. Dr. Lees was appointed the company's chief geologist and engaged in survey work in many countries. His discovery of oil-bearing sands on the coast of Dorset led to British Petroleum prospecting for oil in Britain, the discovery of the Eakring oilfields in 1939 and other fields in 1941-42.

Samuel J. Maddin, Sr., pioneer in the natural gas industry in the Owensboro, Kentucky, area, died recently in Owensboro. He was a member of the firm of Shipp, Maddin & Parrish, later known as the Missouri-Kansas Pipe Line Company and Kentucky Natural Gas Corporation, Kentucky Natural and Memphis Natural Gas Company were later formed into Texas Gas Transmission Corporation.

John Huegel, vice president of Bodie-Hoover Petroleum Corporation, Chicago, Illinois, died recently. Formerly with Waters Pierce Company and the Union Petroleum Company, Huegel organized his own firm, the Huegel-Gustafson Oil Company, which was absorbed by Bodie-Hoover in 1938.

John Rodgers Moroney, president of Petroleum Southwest Company and Petroleum Royalty Corporation, died February 16 in Dallas, Texas.

Gordon Allen, sales representative for Magcobar, died recently in Shreveport, Louisiana. A veteran of more than 25 years in oil field service and supply work in the Ark-La-Tex area, Allen had been employed by Magcobar since 1950.

Andrew Krow, president of White Krow Oil Company, died from a heart attack at his home in Ralston, Oklahoma. In addition to his oil interests, Krow was a rancher and extensive land owner.

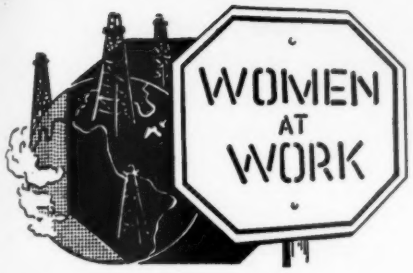
Paul S. Nunley, general traffic manager of Phillips Petroleum Company, died in a St. Louis, Missouri, hospital. He had been with the Independent Oil Company and was transferred to Bartlesville, Oklahoma, when that company was purchased by Phillips.

Neil Stallard, pipe line field superintendent for Pelican Crude, Incorporated, at Lake Charles, Louisiana, died February 8 of a heart attack at his home near Lake Charles. He was formerly employed by Prairie Pipe Line Company at Independence, Kansas, and was district superintendent for Continental Pipe Line Company prior to becoming employed by Pelican. He started in the pipe line business with Prairie in 1916.

James Bowles, former director, secretary and technologist of Crown Central Petroleum Corporation, died recently in Baltimore, Maryland. He had been associated with Crown from 1925 until his retirement in April.

Clair J. Gibson, prominent oil developer in California and Texas, died recently. Gibson was owner of Coast Exploration and a partner in Coast-Gibson Oil Operations.

Z. L. (Zed) Phelps, veteran California oil man, died recently in Coalinga.



Technician at Sun

To the casual observer, a mass spectrometer with its dials, gages, dimly-burning vacuum tubes and many controls is a completely puzzling, complex electronic instrument.

But for attractive Mrs. Evelyn P. Remorenko, skilled in its operation, the complicated mass spectrometer in the Podbielniak Laboratory at Sun Oil Company's research and development department, Marcus Hook, Pennsylvania, poses no problem.

Evelyn uses the mass spectrometer almost daily to analyze light refinery hydrocarbons in Sun's research activities and is regarded as an expert in its operation.

She joined Sun in 1942 as a laboratory technician and later spent some time at the University of Pennsylvania learning to operate an experimental mass spectrometer there. In 1947 an instrument was installed at Sun, and Evelyn has operated it ever since.

Although Evelyn has had no formal technical training, she has done some maintenance work on the instrument in addition to her operational duties.

She recalls having closed down the equpiment, when a faulty filament had halted operation. She pressured the necessary areas with helium to maintain instrument pressure so that the filament could be changed. Checking equipment is part of her duties.

Off the job, Evelyn's favorite occupations are needlework, home decorating, bridge and dancing. She makes her home with her husband at 5 Gladstone Road, Wallingford, Pennsylvania.

"Big" operator.

Micropalaeontologist

In 1943 Diane Loranger, a native of Edmonton, was the first girl science student to be graduated in geology at the University of Manitoba. Today, at 33, she holds a responsible supervisory position with Imperial Oil's geologic research group and has gained a place of respect among the geological profession in western Canada.

Diane has worked as a field geologist, as a resident geologist at the sites of drilling wells, and upon interpretive work in a central office. She has specialized in the study of microscopic fossils, and is known to the profession as a micropalaeontologist —or foramiferologist.

In spite of her mere 118 pounds, her diminutive five feet five, her hazel-brown eyes and girlish dark brown hair, she has undertaken jobs that require exceptional strength and endurance. A vigorous sportswoman, she also has held a private pilot's license and belonged to two flying clubs.

A list of her club affiliations and other activities indicates that she puts into practice her belief that a full and useful life is a happy one. She is a member of the Big Sisters organization in Calgary, she is an enthusiastic worker with the Esso Club, and she is geologic editor of the news bulletin of the Alberta Association of Petroleum Geologists. She has belonged to bowling, riding, tennis and ski clubs, and currently is a member of two golf clubs—Inglewood and Canyon Meadows.

Diane has a field day.

Typical of her self-reliant approach to life was her action when she encountered persistent mechanical trouble with a second-hand car—she simply took a mechanic's course and now does her own repair work.

Miss Loranger has shirked none of the tasks assigned to male geologists and as a member of a field geological party has walked as much as 14 miles in a day. Her fossil study has achieved for her a supervisory position.

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For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(1) MECHANICAL SEAL

Byron Jackson Company has announced a new high temperature mechanical seal designed and tested to handle the rugged requirements of refinery service, including hot asphalt and hot oil pumping up to temperatures of 800 F. Seals are available in any pressure encountered in refinery operation.

Circle number (1) on reply card.

(2) CUSHMAN ELECTRIC

Cushman Motor Works, Inc. has announced the addition of the Cushman 730 Electric to its line of two and three-wheeled vehicles. Company officials say that it is ideal for use in oil fields, and refineries, railroad terminals, etc. The 730 is powered with four automotive batteries and a ¾-hp traction type motor. A battery charger and cable come as accessory equipment.

Circle number (2) on reply card.

(3) QUICK-SEAL COUPLING

Titeflex, Inc., has developed a quick-seal coupling designed to cut labor and time and increase safety in unloading tank cars. U.S. Steel Corporation's Homestead District Works has reported that use of the coupling reduced the time for hose-to-tank car connection from half an hour to a few minutes. Also, the firm reported that the new coupling eliminated leakage at the car connection, thus increasing safety.

Circle number (3) on reply card.

(4) WELLCHECKER

A new wellchecker, designed to automatically separate, sample, meter and accurately record for tax and royalty records the amount of oil, gas and water from wells producing up to 1000 bbl per day liquid and 3000 Mcf gas has been added to the standard line of wellcheckers developed by Rolo Manufacturing Company. In the new unit, known as the Rolo

Wellchecker No. 1H-2406-18, crude from the wellhead is separated into three phases of oil, gas, and water in the wellchecker. Oil flows from the separator into the Rolocheck meter, where it is accurately measured, and is automatically sampled while meter is dumping.

Circle number (4) on reply card.

(5) TAP TOOL

A tap tool for high speed, super sensitive tapping of 0-80 to 4-40 holes in steel and other materials and plastics has been placed in production by Armite Laboratories. It consists of a Morse No. 2 tapered shank with a telescoping spindle which provides for vertical travel of the tap, a knurled control collar to provide maximum "feel" of the tapping operation, and a lock screw arrangement which engages an overload clutch for small taps and disengages for No. 2 and No. 4 taps.

Circle number (5) on reply card.

(6) CAT NO. 583

Caterpillar Tractor Company has developed the Cat No. 583 Pipelayer, after five years of research and testing. Caterpillar, with four other pipelayers already on the market, claims the title of "most efficient" for the unit because it is the first such machine engineered from the group up as a pipelayer. Also, Caterpillar said the No. 583 has a lifting capacity of 130,000 lb, more than any other pipelayer; a 21-in. ground clearance, highest in the field; a new power take-off which permits power to be routed directly to the pipelayer master clutch; a new engine delivering 190 engine hp at 1200 rpm, and superior stability with 86-in. gage, 28-in. track shoes, seven-roller track frame and an overall length of 211½ in. Engine and boom are centered and counterweights are split fore and aft.

Circle number (6) on reply card.

(7) VACUUM VOLTMETER

A new self-contained vacuum tube voltmeter (model 982), adaptable where the requirements of peak to peak measurements exclude the use of conventional meters, has been introduced by the Weston Electrical Instrument Corporation. Battery operated, it is said to be completely isolated from spurious response due to stray a-c fields and circulating ground currents.

Circle number (7) on reply card.

(8) GEOPHYSICAL CABLES

Vector Manufacturing Company has announced the development of a new series of rubber-jacketed, nylon insulated geophysical cables. Developed for use in extreme hot or cold temperatures, the extruded jacket is compounded from 60 per cent natural rubber.

Circle number (8) on reply card.

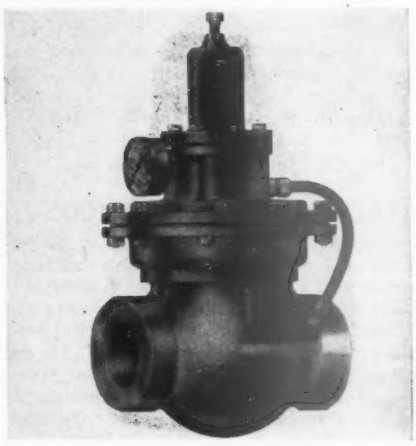
(9) ALLOY VALVES

A new line of alloy gate, globe, and angle valves has been announced by Crane Company. Features of the new line are a split-wedge disc design in the gate valves and an improved disc-stem connection in the globe and angle valves. Valves are regularly available in Crane 18-8S Mo stainless steel and Craneloy 20 high-nickel, high-chromium stainless steel.

Circle number (9) on reply card.

(10) PRESSURE REGULATOR

Black, Sivalls & Bryson, Inc., has introduced the type 73-22 back pressure regulator with integral controller for services where close regulation and complete closure are required in a single instrument.



Designed for optimum control on low pressure oil separators, water knockouts, gunbarrels, gas gathering lines and other equipment requiring close pressure control as well as tight shutoff, the BS&B Type 73-22 is said to work equally well, within its pressure limitations, in all gas or air services that require back pressure regulation.

Circle number (10) on reply card.

(11) CONVERSION KIT

J. & S. Carburetor Company has presented an engineered kit for converting Fords to LP gas. The kit, designed for 1954 Y-block Ford V-8 cars and '54 Ford V-8 trucks, F-100 through F-600, was designed for easy installation, manufacturers say. Water hoses are eliminated.

Circle number (11) on reply card.

(12) SPEED-O-MATIC CONTROL

Modern speed-o-matic controls are available for the first time on heavy-duty, ¾-yd machines with the introduction of the LS-88 shovel-crane by the Link-Belt Speeder Corporation. The maker states that its new machine offers the most speed and power in its class.

Circle number (12) on reply card.

(13) INDUSTRIAL FLASHLIGHTS

Two new heavy-duty, industrial-type flashlights—one a new approved Safety Type—have been announced by National Carbon Company. Manufacturer recommends them for use by railroads, public utilities, refineries, chemical plants, and other industries requiring rugged dependability, long life and safe operation. The new Eveready heavy-duty flashlight has an insulated ethyl cellulose case that is said not to shatter, crack or dent and to be resistant to temperature extremes.

Circle number (13) on reply card.

New Equipment

(14) VLF SYSTEM

A new very low frequency seismic refraction system—with special amplifiers linear from one to 50 cycles and unique refraction seismometers with a natural frequency of two cycles per second—has been announced by Houston Technical Laboratories. All components of the VLF System—amplifier, seismometers, blaster, power supply, recording oscillograph, and cable reel—are designed and manufactured by HTL.

Circle number (14) on reply card.

(15) MIST COLLECTOR

Dollinger Corporation has announced the new Electro-Staynew mist collector for eliminating oil mist and smoke at its source. Designed to be mounted on or near high speed grinding and cutting machines the mist collector is designed to remove over 90 per cent of oil mist and smoke and return clean air to the shop. Completely self-contained, the unit provides a "packaged" ventilating system for individual machine tools.

Circle number (15) on reply card.

(16) POWER-DRIVEN STUDS

Development of a new Ramset heavy-duty power-actuated tool capable of driving a stud through one inch of structural steel has been announced by Robinson-Hannagan Associates, Inc. The firm said the first successful application of the powder-actuated method of fastening lead lining to heavy steel has been completed at a large mid-western refinery. The new process is said to be 15 times faster than previous methods of fastening.

Circle number (16) on reply card.

(17) SAFETY SWITCH

The 0-20 Series Murphy safety switch is an addition to the Frank W. Murphy line of safety switches. The 0-20 is designed to automatically shut down an engine if the oil line breaks or the oil pressure drops. Models are available for panel mounting or direct mounting on single magneto ignition, multiple magneto, battery ignition or diesel engines. The 0-20 is available in pressure ranges 0-12; 0-30; 0-75; 0-160 and 0-300.

Circle number (17) on reply card.

(18) BENDING TOOL

Tal Bender, Inc., has announced manufacture of the first portable hydraulic bending tool for bending both pipe and tubing with one bender. Tal equips its hydraulic one shot pipe benders with a newly developed frame, which enables the contractors to bend pipe, rigid conduit, as well as thinwall conduit (EMT), hard and soft copper, aluminum and steel and any other tubing in 90 and 180 deg.

Circle number (18) on reply card.

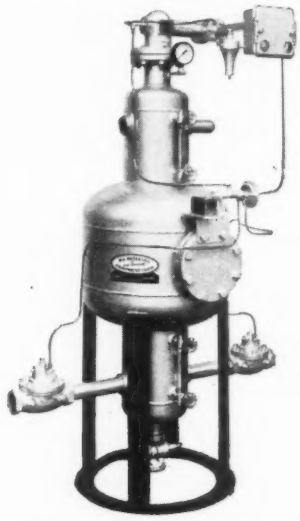
(19) SWITCHING SYSTEM

A new system providing for automatic control of lease operations, manufactured by Garrett Oil Tools, Inc., includes controls, valves and instruments which perform all basic functions of filling storage tanks and opening and closing in wells in accordance with production requirements, storage capacity and pipe line runs. Basically, the system is pneumatically operated, using supply gas pressure of 25 psi or less; however, the pneumatic controls can be switched to electrical operation when desired.

Circle number (19) on reply card.

(20) OIL METERING

Accurate metering of crude runs is provided by a new type of metering vessel marketed by Oil Metering and Processing Equipment Company under the trade name of Vol-u-meter. This unit measures liquid by cyclic accumulation, isolation and discharge of equal volumes, with the number of cycles registered and totalled



on a mechanical counter. Vol-u-meters are furnished in two types: Type C with an external piston or rotary snap-acting pilot, for operating pressures of 125 to 230 psi; and type B with torsion tube liquid level control for operating pressures of 125, 230, 600, 1200, 1500 and 2000 psi.

Circle number (20) on reply card.

(21) HYDRAULIC MOLDBOARD

A hydraulic shiftable moldboard has been introduced by the Tractor division of the Allis-Chalmers Manufacturing Company as an additional accessory for its Model D Motor Grader. The power-shift moldboard, similar in design to the hydraulic moldboard of the AD-40 motor grader, permits a side shift of 16 inches right or left—a total of 32 inches. The blade can be shifted from the operator's seat.

Circle number (21) on reply card.

(22) SLUSH PUMP

Available now after more than five years of field tests, the new IDECO 600 hp duplex 7¼ by 16 slush pump is specifically designed for higher plunger loads required in modern jet drilling. The new pump is engineered for stamina to produce higher volumes continuously with lower maintenance costs. All-steel construction makes possible a high hp-to-weight ratio. With expendables, less sheave, the Mud-Master weighs 30,150 lb.

Circle number (22) on reply card.

(23) PROCESS PUMPS

Interchangeability of parts is one of the outstanding features of a newly re-engineered line of single stage, end suction, centrifugal process pumps by Dean Brothers Pumps Inc. Features such as the enclosed cradle; drain rim base; labyrinth, non-sparking bearing seals; rabbetted joints; alloy steel studs; and stuffing boxes interchangeably adapted to packing or mechanical seal are standard construction in these pumps.

Circle number (23) on reply card.

Another Job Done Better With The ALL-NEW 'Jeep'®

BACKFILLING

Equipped with a hydraulically-controlled blade, the 'Jeep' is an efficient backfiller. Shown here is a blade mounted on a 'Jeep' trencher—a single power unit that does both trenching and backfilling. Get details at your 'Jeep' dealer.

WILLYS MOTORS, INC.
TOLEDO 1, OHIO

The 'Jeep' Family of 4-Wheel-Drive Vehicles . . UNIVERSAL 'JEEP' • TRUCK • STATION WAGON • PANEL DELIVERY

THE WORLD'S MOST USEFUL VEHICLES

(24) AIR STARTING MOTOR

Ingersoll-Rand, manufacturer of air starting motors for diesel and large gasoline engines, has announced a third size starting motor. Motor is known as the Size 5BM and is designed for starting service on gasoline engines with from 750 to 1750 cu in. displacement and for diesel engines from 300 to 700 cu in. displacement.

Circle number (24) on reply card.

(25) SEAMLESS VALVES

H. N. Hartwell & Son, Inc., has announced the addition of all-molded, seamless valves to its line of pipe, fittings, rods, blocks, sheets and special fabrications sold under the Boltaron 6200 trade name. The valves are the first of their kind designed and engineered by The Lunkenheimer Company. The valves and standard I.P.S. fittings in sizes ¼ to 2 in. are said to be resistant to most industrial chemicals and complement the line of Boltaron 6200.

Circle number (25) on reply card.

(26) PRITCHARD COOLING

J. F. Pritchard & Company, has introduced a new line of mechanical draft cooling towers for air conditioning and small industrial applications. This new "Lo-Line" induced draft tower has been specifically designed to solve two problems. First, with its low overall height and exterior casing of corrugated cement asbestos board, it meets the trend toward suburban building of longer, lower-lined buildings. Secondly, it answers the demand of metropolitan buildings where cooling towers are still mounted on the roof.

Circle number (26) on reply card.

(27) GRALOC VALVES

The new stainless steel Graloc vent-drain-bleeder valve in sizes ½ and ¾ in. has been designed for 20,000 psi safe working pressure or temperatures up to 1200 F by Gray Tool Company. It may

be used for vents and drains at the high and low points of piping, equipment and instruments, to bleed at double block valves, and as freeze drains, try-cocks and sample connections.

Circle number (27) on reply card.

(28) COOLING TOWER

The cooling tower division of Santa Fe Tank and Tower Company, Inc. has announced the manufacture of a new prototype in cooling tower design. Representing a rearrangement of a standard tower's component parts, the new Santa Fe "Windtrol" is said to offer the distinct advantages of improved operating efficiency by controlling recirculation and increased functional life span with reduced maintenance requirements.

Circle number (28) on reply card.

(29) INTEGRATOR

Rockwell Register Corporation has announced development of an integrator said to be eight times faster than any other method of chart calculation. The unit is designed for sustained accuracy.

Circle number (29) on reply card.

(30) NEW PERCUSSION TOOL

American Percussion Tool Company has announced development of a rotary-percussion type drilling tool. Company engineers report tests have shown a drilling rate several times as fast as that of conventional rotary tools.

Circle number (30) on reply card.

(31) BRIDGE PLUG

An improved plug for use in blanking off oil well casing sections has been developed by McCullough Tool Company. The bridge plug is used when it becomes necessary to seal off the perforations which are made in the casing to allow the oil and gas to flow or be pumped to the surface.

Circle number (31) on reply card.

(32) CLEARING ATTACHMENT

The Homelite Corporation announces a new, low-cost attachment that converts the Homelite Model 17 Chain Saw into an all-purpose clearing unit. Exclusive with Homelite, the new Clearing Attachment is recommended for pipe line companies.

Circle number (32) on reply card.

(33) GATE VALVES

A newly designed line of bronze gate valves for general full-flow service on steam, eater, oil or gas has been announced by the R-P&C Valve Division, American Chain & Cable Company.

Circle number (33) on reply card.

(34) FRACTIONAL HP MOTORS

A completely redesigned line of fractional horsepower motors in the NEMA 48-frame size is available from Westinghouse Electric Corporation. The motors range in rating from one-sixth through one-third horsepower.

Circle number (34) on reply card.

(35) DEMI VALVE

The George W. Dahl Company has announced the design and manufacture of their toggle-actuated Demi valve. This valve is available in either bronze, aluminum, steel or stainless steel body with a neoprene diaphragm. Bonnets can be threaded on the OD for panel mounting.

Circle number (35) on reply card.

(36) W-266 POWER UNIT

Allis-Chalmers Manufacturing Company, Tractor Division, has redesigned its W-226 heavy duty power unit with a resulting increase in maximum brake horsepower and performance. The new unit when operating on gasoline will develop a maximum 60 brake hp at 1800 rpm and 50.6 bhp at 1400 rpm.

Circle number (36) on reply card.

(37) PORCENELLS

Vitreco, Inc., a research company jointly owned by Poor & Company, and Youngstown Sheet & Tube Company, has developed Porcenells, a line of inorganic silicate coatings for fusing to ferrous metals.

Circle number (37) on reply card.

Another Job Done Better With The ALL-NEW 'Jeep'®

TRENCHING

This 'Jeep'-propelled trencher digs trenches up to 5 feet deep at the rate of 300 feet an hour. Mounted on the 'Jeep' and powered by its *Hurricane* Engine, it gets to the job in a hurry, speeds up the laying of pipe, cable or drain tile. Traveling at road speeds to the job, the unit is ready for trenching in a matter of minutes. Greater mobility makes the 'Jeep' trencher profitable for short runs of trench. It will pay you to investigate all the time-saving advantages of the 4-Wheel-Drive Universal 'Jeep'.

WILLYS MOTORS, INC.
TOLEDO 1, OHIO

The 'Jeep' Family of 4-Wheel-Drive Vehicles . . . UNIVERSAL 'JEEP' • TRUCK • STATION WAGON • PANEL DELIVERY

THE WORLD'S MOST USEFUL VEHICLES

XUM

NEW oil and gas Literature

- Brochures
- Bulletins
- Catalogs

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(38) HIGH ALLOY CASTINGS

To aid designers in the use of high alloy castings, the Alloy Casting Institute has made available reprints of the paper, "Resistance of Cast Fe-Cr-Ni Alloys to Oxidizing and Reducing Flue-Gas Atmospheres." Reprinted from the *Transactions* of the ASME, the paper is seven pages long and includes numerous figures.

Circle number (38) on reply card.

(39) ALCO REVIEWS

Publication of the Winter issue of the Alco Products Review has been announced by American Locomotive Company. The magazine, directed to the petroleum, chemical and power fields, contains articles on Air Reduction Corporation's Riverton plant and on the new Lincoln tunnel construction.

Circle number (39) on reply card.

(40) HEAVY-DUTY ENGINES

Eighteen heavy-duty power units are described in a catalog published by the International Harvester Company. The engines have a range of from 16.5 to 200 net hp.

Circle number (40) on reply card.

(41) LUBRICATING OILS

The development of more efficient lubricating oils to get many years of reliable service from diesel engines is related in a new booklet, Let Your Diesel Live, by Caterpillar Tractor Company.

Circle number (41) on reply card.

(42) POWER OPERATORS

Conoflow Corporation, has issued Bulletin B-50-2, a 12-page booklet describing the Cylinder Conomotor, pneumatically positioned power operator for throttling control service. This bulletin illustrates the versatility of the Cylinder Conomotor and its applications including proportional control of speed changers, valves, pumps, and electrical components.

Circle number (42) on reply card.

(43) URANIUM CHART

Correlation Chart of Uranium Bearing Minerals has been prepared by Colorado School of Mines Research Foundation, Golden, Colorado. The chart, 50 by 32 inches, lists more than 160 uranium bearing minerals, so located on the chart as to disclose their chemical composition. Enough characteristics are given to permit positive identification of each mineral.

Circle number (43) on reply card.

(44) CASING SUPPORT

Operating features and design of National Type A casing supports are illustrated in Bulletin 432 issued by National Supply Company. Specifications cover 12 sizes of 65,000 to 160,000 lb capacity.

Circle number (44) on reply card.

(45) CASING HEADS

Features of National Type D casing heads for suspending and independently sealing single casing strings weighing up to 200,000 lbs are presented in Bulletin 433 by The National Supply Company.

Circle number (45) on reply card.

(46) FUEL OIL

Proportioneers, Inc., division of B-I-F Industries, Inc., has issued an application memo on "The Continuous Blending and Proportioning of Fuel Oils." This memo, with diagrams and descriptions, illustrates the manner in which a newly-developed two component blender automatically delivers a uniform blend of No. 5 fuel oil directly into tank trucks, tank cars, ships or storage.

Circle number (46) on reply card.

(47) PUMP DESIGN

A 12-page paper detailing the design and development of centrifugal pumps that have no seals or stuffing boxes has been published by Chempump Corporation. The article covers design history, early experimental work and outlines the basic problem of building an electric motor inside a pump.

Circle number (47) on reply card.

(48) DIESEL ENGINES

A brochure describing the operation of General Motors 6-10 diesel engines and illustrating models in the series from 200 to 575 hp is ready for distribution by Detroit diesel engine division. Entitled Power for Progress, the brochure covers features of design, specifications and power curves of single, multiple-engine, and torque converter units.

Circle number (48) on reply card.

(49) SCALE CORRECTIVES

D. W. Haering & Company, Inc., has issued a booklet on buying scale and corrosion correctives and controls in "package" form. It describes 11 glucosates, each having a different effective use, which can be ordered by this package method.

Circle number (49) on reply card.

(50) MULTI-STAGE PUMPS

Ingersoll-Rand has published a 12-page, 2-color bulletin describing its vertical multi-stage pumps. It includes sectional drawings, dimensions and installation views of the pumps in service.

Circle number (50) on reply card.

(51) WILLYS ENGINES

A technical bulletin prepared by Willys Motors, Inc., describes two 6-cylinder industrial engines. Power curves, engine specifications, engine illustrations, special features and other pertinent information is included.

Circle number (51) on reply card.

(52) GLYCOL-ETHERS

A new booklet, Cellosolve and Carbitol Solvents, has been published by Carbide and Carbon Chemicals Company, a Division of Union Carbide and Carbon Corporation. This booklet describes in detail the nine commercial glycol-ethers sold by the company.

Circle number (52) on reply card.

(53) SALT SPLITTER

Cochrane Corporation has made available a new publication, No. 4567, on the Cochrane dealkalizing salt splitter. The publication discusses the process of chloride anion exchange, why it is necessary to dealkalize water for boilerfeed and for processing, and shows how water can be dealkalized efficiently and economically with the new Cochrane equipment.

Circle number (53) on reply card.

(54) FORGED STEEL UNIONS

Bulletin U-1, available from Watson-Stillman fittings division, H. K. Porter Company, Inc., describes the company's new forged steel unions. The unions are designed to the dimensional specifications of the Association of American Railroads and are drop-forged of highest quality carbon steel in accordance with ASTM Specification A-105, Grade 2.

Circle number (54) on reply card.

(55) TUBING GUIDE

A general tubing catalog, which condenses into eight pages the pertinent information needed for the selection and application of 46 principal analyses of tubing, has been published by Superior Tube Company. Designated as Bulletin 40, the new catalog groups the 46 analyses into five classifications: (1) stainless steel, (2) nickel and nickel alloys, (3) carbon and alloy steels, (4) beryllium copper and (5) titanium.

Circle number (55) on reply card.

(56) COMBUSTION TURBINES

General Electric Company's combustion gas turbines for power generation and mechanical drive are described in a revised bulletin designated GEA-5516B. Gas turbine-steam turbine cycles, mechanical drive applications, design features, control and governing, generators; tables of characteristics, and dimensions and weights are among subjects covered.

Circle number (56) on reply card.

(57) T3C CONVERTER

The Swartwout Company has announced a new bulletin on the Type T3C Thermocouple-Air Converter. The two-page bulletin, which describes in detail the Type T3C converter, gives data on principles of operation and includes mechanical and electronic specifications, ranges, and a dimensional diagram.

Circle number (57) on reply card.

(58) COMPRESSORS

A four-page bulletin illustrates and describes features found on the 85 cfm Airmaster produced by Le Roi division, Westinghouse Air Brake Company. A cross section view of the one unit engine-compressor is given, also specifications for the compressor and engine.

Circle number (58) on reply card.

(59) INDEX FOR VALVES

Valve users and buyers can obtain data on valves for a wide variety of applications by using the new cross index in Condensed Catalog 105 published by Edward Valves, Inc., subsidiary of Rockwell Manufacturing Company.

Circle number (59) on reply card.

(60) MULTI-V-DRIVES

Worthington Corporation has released a new master engineering manual on multi-V-drives. The 100-page manual presents a scientific and simplified method for rating V-belts. Each popular 60 cycle motor speed with complete drive selections is shown on separate pages.

Circle number (60) on reply card.

(61) LIFT CRANE

Following the production anouncement of a new excavator in the 20-ton lift capacity class, Koehring Company has published an 8-page catalog to illustrate and describe the construction features, work capacity and application of the heavy-duty excavator. The new machine is designated as the Model 405.

Circle number (61) on reply card.

ARMSTRONG BROS.
Better PIPE TOOLS

PIPE CUTTERS

"ARMSTRONG BROS." Three wheel and Standard wheel and roller Pipe Cutters are quality cutters throughout . . . built to give years of good service.

"ARMSTRONG BROS." drop forged Pipe Cutters are built for lifetime service with 1-piece drop forged steel heat treated body and a replaceable hardened steel nut to take up the wear and thrust to handle screw. Used either as 1-wheel (with 2 rollers) or 3-wheel (for close quarters).

"ARMSTRONG BROS." Knife Blade Cutter Wheels are machined from special alloy tool steel properly heat treated. They cut rapidly and easily, hold their keen edge.

Write for Catalog

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
5231 W. ARMSTRONG AVENUE • CHICAGO 30, ILL.

(62) RUST-OLEUM

Rust-Oleum Corporation has released a 1955 general catalog which provides a treatise on rust prevention and is dedicated to showing all types of industry how to stop rust. The enlarged catalog features 98 color chips of Rust-Oleum products and includes instructions for surface preparation and application.

Circle number (62) on reply card.

(63) 2000-MC MICROWAVE

A description of 2000-mc microwave-radio systems for a variety of applications is given in an 8-page booklet available from the Westinghouse Electric Corporation. Features of Type-FR microwave radio and Type-FJ multiplexing equipment and their importance to the overall system is discussed.

Circle number (63) on reply card.

(64) SWITCHES

A new 12-page catalog covering Micro Switch Subminiature snap-action precision switches, auxiliary actuators, subminiature switches, toggle and push button subminiature switch assemblies has been publisher by Micro Switch, a division of Minneapolis-Honeywell Regulator Company. The catalog, No. 75, also describes two new switch designs, the (SL) subminiature slide switch, operating two SPDT basic switches, and a line of subminiature rotary selector switches.

Circle number (64) on reply card.

(65) MEASUREMENT EQUIPMENT

Rockwell Manufacturing Company has issued a new booklet describing the design and operation of a new line of Rotocycle stainless steel industrial meters for specific applications in the food, chemical, petrochemical, industrial, pharmaceutical and processing fields.

Circle number (65) on reply card.

(66) SUSPENSION DRILLING

Bekco Oil Tool Company offers a descriptive bulletin on its suspension drilling tool said to assure a straight hole and increase overall rig efficiency in deep drilling. Reciprocating action of this drill collar allows full suspension of the drill pipe. Service offered in U. S. only.

Circle number (66) on reply card.

(67) FILTRATION

Engine Life Products Corporation has published the first of a series of engineering discussions titled "Filter Facts," telling of the service the firm offers to engine manufacturers and operators. The 12-page book gives filtration fundamentals.

Circle number (67) on reply card.

(68) DOUBLE VOLUTE PUMPS

Bingham Pump Company has released a technical publication on the advancement of centrifugal pump design. Drawings and photographs illustrate the structure and applications of the firm's double volute pumps.

Circle number (68) on reply card.

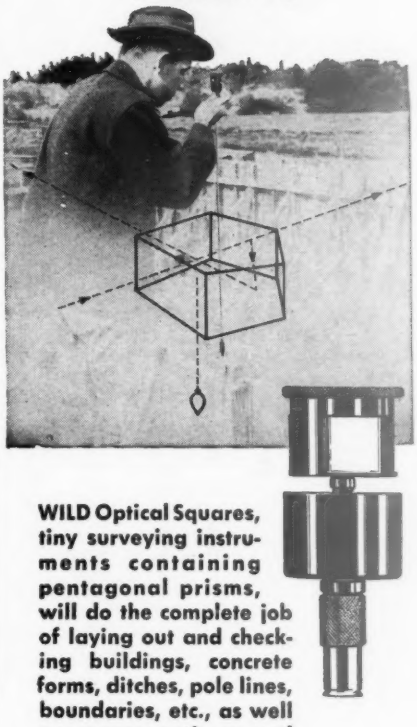
(69) ARC FURNACE ELECTRODE

The Askania Regulator Company's system of hydraulically positioning arc furnace electrodes is described in bulletin No. 162. The electrodes are designed to react simultaneously to an electrical signal proportional to arc impedance.

Circle number (69) on reply card.

FOR THE "RIGHT" ANGLES USE

OPTICAL SQUARES THE "WATCH POCKET" TRANSITS



WILD Optical Squares, tiny surveying instruments containing pentagonal prisms, will do the complete job of laying out and checking buildings, concrete forms, ditches, pole lines, boundaries, etc., as well as cross sections and topo maps.

These handy tools actually fit your watch-pocket. They require no field adjustment and little or no practice for use.

Single Pentagonal Prisms $19.00
Double Pentagonal Prisms $26.25
Plumbing Rod (Optional) $26.25
(Plus Postage)

For Detailed Information Regarding the "Why and How" of Optical Squares Request Booklet PT 3.

Full Factory Service by Specialists

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FOR THE *Best*

JOHNSTON VERTICAL PUMPS

IN BOOSTER LINE SERVICE

use JOHNSTON vertical turbine pumps

Setting a high standard for excellence, Johnston Vertical Turbine Pumps are widely used for booster line service for pipelines, refineries, and chemical plants throughout the world. Unlimited flexibility of installation, with discharge heads to fit any system, makes these pumps highly popular with design engineers. For crude oil, gasoline, diesel fuel, ammonia, L-P gases and other volatile fluids, Johnston Pumps are dependable, easy to install, economical to operate.

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☐ Send Bulletins

☐ Have Representative Call

Name.....

Address.....

City.....Zone.....State.....

PE-35

Trade Literature

(70) OIL FIELD SERVICE

Dowell Incorporated has published a four-page pamphlet giving "15 reasons" for Dowell oil field service. Pictures and equipment with specifications and descriptions are included.

Circle number (70) on reply card.

(71) INSULATION

Forty-Eight Insulations, Inc., has published a booklet giving specifications for vessel insulation. It was designed to provide materials' standards, to insure the quality of insulating fiber filler, and to offer a practical method for the insulation of vessels.

Circle number (71) on reply card.

(72) FORGED STEEL UNIONS

Watson-Stillman Fittings division of H. K. Porter Company, has published Bulletin U-1 on forged steel unions. Unions are shown in photographs and cutaway drawings and specifications are given.

Circle number (72) on reply card.

(73) TUBULAR PRODUCTS

A catalog on Spang-Chalfant oil country tubular products has been released by the Spang-Chalfant division of The National Supply Company. Detailed descriptions, specifications and drawings through the 50-page book illustrate the firm's line of tubular products.

Circle number (73) on reply card.

(74) CHEMICAL FEEDING

A folder on the feeding of chemicals has been published by Hall Laboratories, Inc. Examples are given of tube failures, plugged feed lines, and other troubles caused by ill-advised chemical feeding by inexperienced personnel.

Circle number (74) on reply card.

(75) SOLENOID VALVES

One-page Bulletin F-1 illustrates and describes the new direct lift solenoid valves made in brass (type F) and stainless steel (type G) by J. D. Gould Company. Designed for general service, the new valves are made in ⅛ and ¼-in. pipe sizes, with ports from 1/16 to ¼-in.

Circle number (75) on reply card.

(76) GRALOC LINE

A 12-page, 2-color, combination engineering manual and catalog describes the new Graloc line of universal pipe connections, unions, and bleeder valves. The booklet describes a new concept of all-steel sealings.

Circle number (76) on reply card.

(77) WEATHERFORD TOOLS

A 42-page catalog, with color illustrations, completely describing the Weatherford line has been released by the Weatherford Oil Tool Company, Inc. Complete with engineering data, it contains the recommended procedure for the use of Weatherford equipment.

Circle number (77) on reply card.

(78) VERTICAL PUMPS

A 16-page bulletin which describes and illustrates the application of Peerless vertical industrial pumps for liquid transfer from short settings in both industrial and process services has been published by Peerless pump division, Food Machinery and Chemical Corporation.

Circle number (78) on reply card.

OIL and GAS TRADE NEWS

Parker Names Distributor

General Sales, Inc., Amarillo, Texas, has been franchised as a Parker tube fitting distributor by The Parker Appliance Company, Cleveland, Ohio.

Failing Company Sold

The George E. Failing Company of Enid, Oklahoma, a wholly-owned subsidiary of Westinghouse Air Brake Company of Pittsburgh, Pennsylvania, has purchased from George E. Failing and his brother, Harry Q. Failing, all stock of the George E. Failing Supply Company, Ltd., of Edmonton, Alberta, Canada. (The Canadian company was not included in the purchase made in April, 1953, when Westinghouse acquired all other properties then being operated by the George E. Failing Supply Company.)

Rockwell Research Expands

Rockwell Manufacturing Company has planned a 50 per cent expansion of its research and development program. According to C. A. Wiken, vice president of engineering and research, the company is concentrating heavily on electrical research for the first time—in addition to mechanical research, also the company is opening its first atomic energy engineering training course.

B&W Adds Department

The Babcock & Wilcox Company has formed a new department in the boiler division which consolidates the contract and erection phases of the division's operations. The new department, to be known as contract and erection, will be located in a new office building soon to be built a short distance away from the company's largest manufacturing plant in Barberton, Ohio. Laurence H. Hayward has been named manager of the new department.

L&H to Build

Leeds & Northrup Company has announced that the contract for construction of its new plant adjoining North Wales, Pennsylvania, approximately 22 miles from the heart of Philadelphia, has been awarded to Baton Construction Company, Philadelphia. The contract is for approximately $2,750,000. Occupancy is scheduled for the winter of 1955-56.

Wolverine Has Seminar

A two-day seminar entitled "Opportunity" and devoted to Wolverine Trufin, the integral finned condenser tube, was conducted by Dr. Donald L. Katz, professor of chemical engineering on the faculty of the University of Michigan, announced C. T. Fuller, southwestern sales manager for Wolverine Tube, division of Calumet & Hecla, Inc.

Gardner-Denver, Keller Join

Managements of the Gardner-Denver Company, Quincy, Illinois, and of the Keller Tool Company, Grand Haven, Michigan, have announced that the stockholders of both companies have approved a consolidation. Keller Tool Company now becomes the Keller Tool division of Gardner-Denver Company.

Denver Plant Announced

Hill, Hubbel and Company has opened a new plant in Denver, Colorado. Located on a 20-acre site, the new Hill, Hubbell mill is said to be the largest operation of its kind between Chicago and the Pacific Coast. Pipe from Colorado steel pipe mills, as well as from the East and far West, will be processed in the new Denver plant and delivered to construction projects throughout the western states.

Turbine Is Representative

The Turbine Equipment Company, Glen Falls, New York, announces its appointment as representatives for the Cochrane Corporation, of Philadelphia, Pennsylvania. Equipment manufactured by Cochrane and handled by Turbine Equipment Company will include Deaerating Heaters, Continuous Blow-down Systems, Multiport Relief Valves, Condensate Drainage and Return Systems, Water Conditioning Equipment, and a variety of Steam Specialties.

National Supply Opens Store

National Supply Company, Limited, has opened an oil well supply store at Drayton Valley, Alberta, Canada. The store will be the fifth operated by the company in Alberta, the others being at Calgary, Edmonton, Redwater, and Stettler. The company also has stores at Virden, Manitoba, and Swift Current and Weyburn, Saskatchewan.

Trane Adds to Plant

The completion of a new plant addition was announced by The Trane Company, La Crosse, Wisconsin, to facilitate the fabrication and distribution of its air conditioning and refrigeration lines. The addition has 50,000 square feet of working area. Trane now has a total of about 975,000 square feet of production area.

Philco Moves Offices

Philco Corporation, government and industrial division, has announced that its western regional headquarters has been moved to new offices in Los Angeles, California. All regional Philco activities relating to military communications, radar and guided missiles as well as television broadcast, microwave communications and industrial field engineering services are centered in the new building at 10589 Santa Monica.

SPI Doubles Trackage

Increased business, and larger shipments from the mills have resulted in Standard Pipeprotection, Inc., St. Louis, Missouri, doubling the length of their yard trackage. The track now in use is sufficiently long to accommodate 25 carloads of pipe, which can be loaded or unloaded in a day, from or onto Spi's layout of skidways. Yard facilities also provide for rapid loading and unloading of trucks.

Pritchard Holds Open House

J. F. Pritchard & Company held open house for the business leaders of Kansas City and out-of-town guests at the opening of its new, modern general office structure at 4625 Roanoke Parkway. The fireproof structure is constructed of reinforced concrete, faced with ledge stone and brick to conform with surroundings.

Lithium Price Reduced

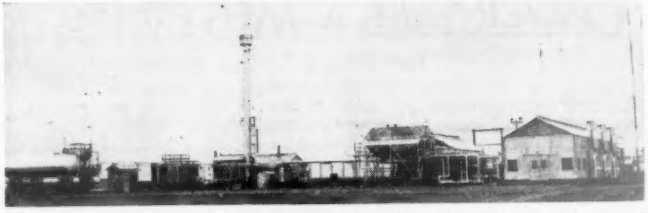
American Potash & Chemical Corporation, a major producer of lithium chemicals and the largest producer of lithium carbonate, has announced a reduction in the price of lithium carbonate from its main plant at Trona, California, from $1.00 per pound to 90 cents per pound, delivered, in carload lots.

Editorial Bureau Set Up

A separate unit charged specifically with improving technical writing has been set up by Consolidated Engineering Corporation, Pasadena, California. John L. Kent, a technical writer and former Washington editor of several industrial and business magazine has been named chief of a newly-organized editorial bureau.

Dresser, Lane-Wells to Merge

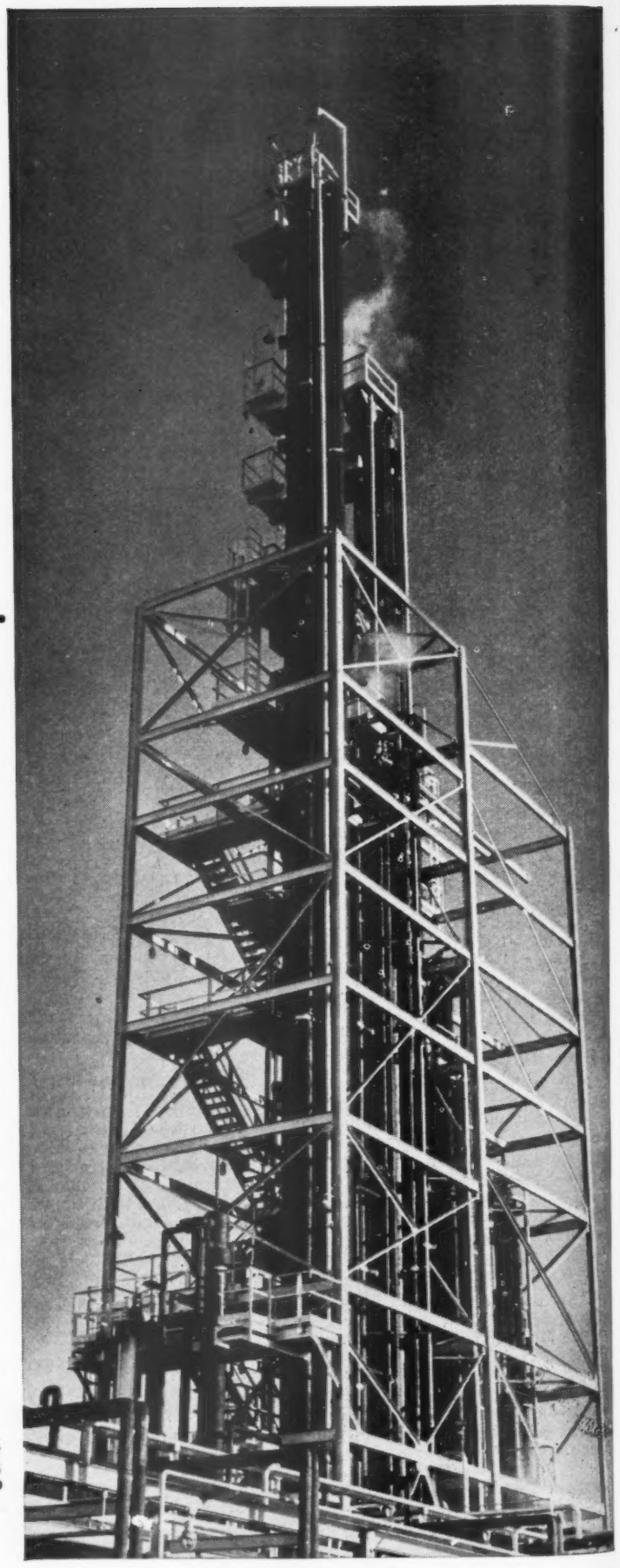
Rodney S. Durkee, chairman of the board of Lane-Wells Company, announced that the board of directors of the company has voted to accept the offer of Dresser Industries, Inc. to exchange 576,000 shares of Dresser Industries common stock for all the assets of Lane-Wells Company, subject to that company's liabilities. In effect the stockholders of Lane-Wells company will receive 4 shares of Dresser Common Stock for each 5 shares of Lane-Wells stock presently held. A special meeting of the stockholders of Lane-Wells will be called to approve the action of the board of directors.



Conservation of 4½ million cu ft of natural gas per day has been made possible through construction of this gas compression and gasoline extraction plant at Sterling, Colorado. Prior to its erection, under the direction of the Chemical Plants Division of the Blaw-Knox Company of Pittsburgh, gas from the Mt. Hope Basin was burned as waste. The plant was built as a joint venture by several major oil firms operating in the Mt. Hope Basin to co-operate with authorities seeking to conserve natural resources.

XUM

Making pure Ethylene from Raw Gas



Here, silhouetted against the sky, are giant distillation and absorber towers in the new Canadian Industries Limited Plant at Edmonton, Alberta. Since late last year this plant has been producing highest purity ethylene from natural gas for use in the manufacture of polyethylene.

These operations involve the recovery of ethane from dry gas by absorption at elevated pressure in a "sponge oil." This "sponge oil" is then stripped of its ethane content which in turn is "cracked." The resulting ethylene is then compressed, dried, separated and purified by fractional distillation at 500 p.s.i., and stored under pressure as a liquid.

Graver fabricated four of these towers to ASME standards for this installation. It was extremely important that such equipment be precision made to eliminate the dangers of leakage and distortion.

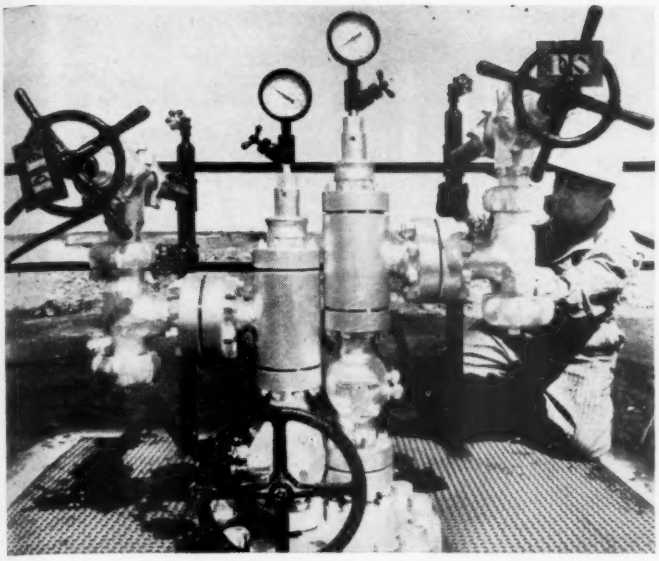
However, Graver is accustomed to fabricating to the highest standards. Towers, tanks, pressure vessels of every kind are built by Graver to satisfy the most exacting needs of the leading chemical and petroleum companies. For *very* highly specialized jobs, call on Graver.

GRAVER TANK & MFG. CO., INC.

East Chicago, Indiana

CHICAGO • NEW YORK • PHILADELPHIA • EDGE MOOR, DEL.
ATLANTA • CATASAUQUA, PA. • PITTSBURGH • CLEVELAND • DETROIT
TULSA • SAND SPRINGS, OKLA. • HOUSTON • ODESSA, TEXAS
CASPER, WYO. • LOS ANGELES • FONTANA, CAL. • SAN FRANCISCO

GRAVER ... *specialists in the fabrication of towers, tanks and process vessels*



This dual completion wellhead assembly manufactured by National Supply Company, is used by the Phillips Petroleum Company, on the Millard Lease, Penwell, Texas. Assembly serves two parallel strings of independently-run 2-in. tubing. Each string produces from different zone. Earlier practice was to flow one zone through the annulus between casing and tubing, and other through tubing.

Pictured here is not only the world's largest trap farm but also the largest installation of automatic plug valve actuators. Manufactured by Pantex Corporation, each plug valve actuator has a solenoid valve which is energized by a time clock. Energizing the valve permits the Pantex Actuator's cylinder to position the plug valve on the line.

Instrument Manufacture Planned

Phillips Petroleum Company, Bartlesville, Oklahoma, and Consolidated Engineering Corporation, Pasadena, California, have concluded an agreement under terms of which Consolidated will manufacture and market continuous plant analysis and control instruments developed by Phillips. The instruments proposed for immediate marketing include infrared gas analyzers, differential refractometers, ultraviolet analyzers. and oxygen analyzers.

Pelton Relocates

The oil industry machinery division of the Pelton Water Wheel Company at Los Angeles, California, announces the relocation of its mid-continent headquarters from Dallas, Texas, to 208 Wright Annex Building, 125 West Third Street, Tulsa, Oklahoma. The Tulsa office is headed by Clyde Lietzow.

FWD Names Counsel

The Four Wheel Drive Auto Company of Clintonville, Wisconsin, has appointed the Lawrence H. Selz Organization, Inc., of Chicago, Illinois, as public relations counsel.

Fifth J&L in Canada

A new store in Canada, at Virden, Manitoba, is announced by Jones & Laughlin Steel Corporation, supply division—the latest of a total of five J&L oil country supply stores in the Canadian Dominions of Alberta, Saskatchewan, and Manitoba. The store is under the local management of Lloyd R. Elston. assisted by William Kotyk.

Welex Opens Office

A new office of Bartlesville, Oklahoma, has been opened by Welex Jet Services, Inc. The office, which will specialize in radioactivity well logging, jet perforating, permanent type completions, and formation fracturing as well as other Welex services, is located at 908 South Oak Street. Manager of the new Welex office is George C. Thomas, Jr.

Bowen Increases Service

S. R. Bowen Company has inaugurated airplane facilities to provide increased customer service and assist company personnel in the performance of their duties. This new service offers a major advantage in that special equipment can be moved to a site where it is urgently required with the least possible loss of time.

Contract Awarded

Northern Chemical Industries, Baltimore, Maryland, has awarded the prime contract for its nitrogen plant at Searsport, Maine, to The Girdler Company, Louisville, Kentucky. Girdler is a division of the National Cylinder Gas Company.

Subsidiary Announced

The American Meter Company, Philadelphia, Pennsylvania, has announced that The Philadelphia Pump and Machinery Company, Inc., has become a subsidiary. President of the subsidiary will remain Joseph A. Eagan.

Tug to Venezuela

The tug, Atlas, recently made a trip to Venezuela with another long tow for Brown and Root, Inc. Last year the tug took three barges of equipment to Haiti. In tow of the Atlas was a converted LST, a 236-ft work barge, and a 110-ft barge.

Atlas Districts Unite

Atlas Powder Company has announced that its New York and Tamaqua, Pennsylvania, explosives sales districts have been consolidated. The new sales area, known as the eastern district, has its headquarters in New York. James R. Russell has been appointed manager of the new district.

Brewster Adds Traveling Blocks

The addition of two new big traveling blocks to the Brewster drilling equipment line has been announced by The Brewster Company, Inc., Shreveport, Louisiana. Built in 400 and 500 ton dead load capacities, the new blocks are designed to meet the extra duty requirements of today's deeper wells.

Jet Process Licensed

Byron Jackson Company has completed negotiations under which Halliburton Oil Well Cementing Company is being licensed to use the jet method of perforating oil well casing. The jet process is a development of the "shaped charge" perfected during World War II for the famed anti-tank bazooka. Following the war Byron Jackson and Welex Jet Services, Inc., became co-developers in adapting the principle to oil production.

Tamco Engineers Appointed

The Cleaver-Brooks Company, Milwaukee, Wisconsin, has announced the appointment of the Tamco Engineers, San Francisco, California, as manufacturer's representative for the sale of Cleaver-Brooks boiler equipment.

DuPont Expands

The petroleum chemicals division of the du Pont Company has established a new sales section and a new technical service group to prepare for new developments in the field of petroleum additives and to improve world-wide customer service, also new sales districts have been formed in Philadelphia, Pennsylvania, and in the Middle West with offices in Detroit, Michigan. The new additives sales group, headquartered in Wilmington, Delaware, will be headed up by R. M. Glover. The technical service group, to operate from the petroleum laboratory at Deepwater Point, New Jersey, will be managed by W. E. Bettoney.

Sales Headquarters Opened

The White Motor Company has opened modern, new truck sales and service headquarters in Pittsburgh, Pennsylvania, at 1136 Western Avenue. Erected at a cost of $500,000, to more efficiently handle the rapidly expanding truck transportation business in the tri-state area of western Pennsylvania, eastern Ohio and northern West Virginia, the new facility replaces White Motor's old outlet and integrates Autocar division's former facility into the enlarged White Pittsburgh operation.

BETZ • *A Great Name*
In Water Conditioning

"Prescriptions" by the truckload!

Solving industrial water conditioning problems effectively and *economically* requires exacting engineering techniques.

There are no stock answers . . . no stock chemical treatments.

We realize this perhaps more than anyone. In fact, we make a business of it.

For example, each year at our mixing and formulating plants in Pennsylvania, Texas, California, and Quebec, we blend and ship thousands upon thousands of different "prescriptions", each specifically job-engineered to solve some individual water conditioning problem for industry. Because we feel it is so important to "tailor-make" our formulations, each of our plants actually performs the function of a giant industrial pharmacy.

The blending and shipment of our chemical formulations is, however, only one important part of our *completely-individualized* water conditioning service. Individual investigations, plant control methods, daily testing programs, periodic checkups, analyses of water samples, and regular engineering reports all combine to provide a water conditioning service that is complete in every detail.

The end result of individual attention to individual problems is obvious . . . the assurance of a plant (perhaps your own) operating at peak efficiency, free from water problems.

A 20-minute, no obligation discussion of your plant water problems with a Betz District Engineer is the best investment in time you can make. Call him in today.

W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: BETZ Laboratories Limited, Montreal 1.

BETZ

■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

Trade News

Pelton Moves

Pelton Water Wheel Company's sales-service facility in Odessa, Texas, has moved to a new location at 421 Grandview Street. H. E. "Gene" Bell will continue to be in charge of the Odessa office and warehouse.

Mill Depot Opens

A new mill depot has been opened by Wolverine Tube, division of Calumet and Hecla, Inc., at Dallas, Texas. The depot will stock Wolverine seamless nonferrous copper water tube, automotive tube and refrigeration tube. C. T. Fuller, southwestern district sales manager, will coordinate the new mill depot operations.

Distributor Named

Pipeline Coating and Engineering Company recently appointed Frost Engineering Service Company, Los Angeles, California, as their distributor for Southern California, Arizona, New Mexico, and southern Nevada. E. Vernon Frost will engage in the engineering and sales of all PLICO products.

Tuloma Plans Headquarters

Tuloma Builders, Inc., of Tulsa, Oklahoma, has announced plans for a new, three-building headquarters southeast of Tulsa. One of the buildings will be a two-story structure, and will house offices and work areas for the firm's engineers, and the other buildings will be used for warehousing, equipment maintenance, welding and fabrication.

GE Uses "Brains"

General Electric has inaugurated a four-way hookup for the rapid processing of engineering and research problems on two giant electronic "brains." Linked in the communications system are GE plants in Evendale, Ohio, where the computing center of the aircraft gas turbine division is using a big IBM 701 on three shifts daily.

Construction Up 7 Per Cent

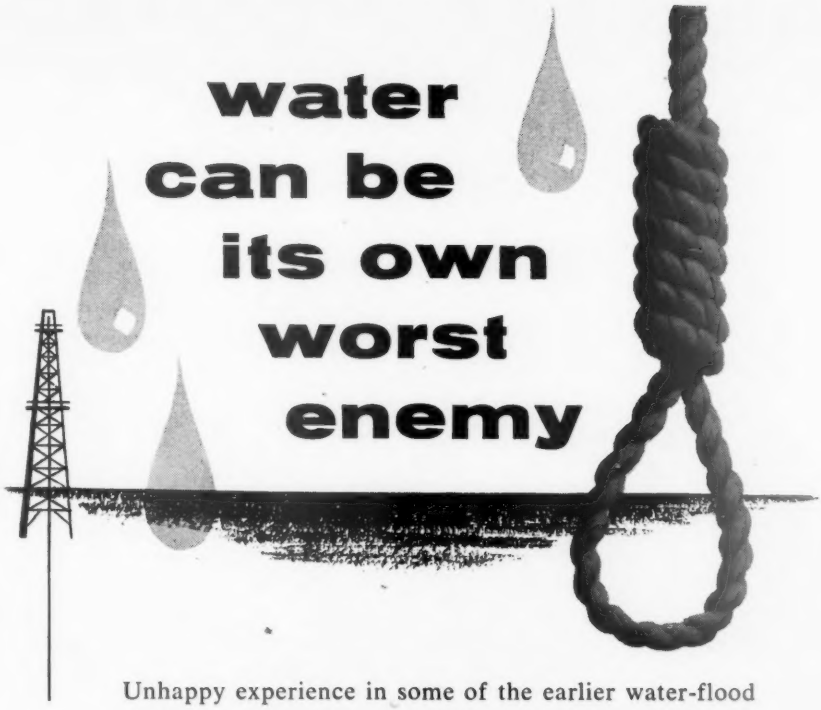
For the building materials industry, 1954 was a year of considerable challenge, according to Herbert Abraham, chairman of The Ruberoid Company. Although construction activity in almost every category went forward at a higher level than the experts had predicted, he said that business was characterized by a return to keen competitive conditions both among the various manufacturers and rival products.

Sherman Sales Up

Sales of Sherman Products, Inc., have reached a new high in 1954, according to figures given to the national sales force of the Royal Oak Company by William F. Beckman, vice president and director of sales. These figures represented sales of the Sherman Power Digger and the Sherman Combination Transmission alone, both attachments for tractors, and will mean a record year for the company.

Equipment Division Created

The combining of the air appliance and industrial filtration divisions of the United States Hoffman Machinery Corporation into a new division to be known as the industrial equipment division, has been announced by Hyman Marcus, president. Marcus also announced the promotion of Revis L. Stephenson, general manager of the air appliance division, to the position of vice president in charge of the new industrial equipment division.



Unhappy experience in some of the earlier water-flood projects has demonstrated that the injection water itself may be the very thing which defeats the project . . .because it can carry into the formation the precipitants, algae and bacteria which have been established as major causes of formation-plugging.

But, today, many of the advanced water-flood projects now in operation have no trouble at all from this source. They have installed modern diatomite filtration systems and, using Dicalite filteraids, are filtering out completely the microscopic water-borne solids which could slow or halt the water drive. That's because Dicalite filtration is so "sharp" that it traps unwanted solids even down in the sub-micron size range: up to 95% of all bacteria can be removed by Dicalite filtration.

Diatomite filtration systems take up little room – about 1/5 that required for the older, less-efficient sand filters – and their installation costs are comparatively low. In addition, diatomite filter systems can be moved to another location when and if desired; in fact, some of the newer systems are completely unitized for easy hauling.

If you'd like your water-flood project to continue at its designed input pressure, instead of watching pump pressures continue to climb, day by day–if you'd like to free your mind of at least one problem in a re-pressuring project – investigate the advantages of Dicalite filtration as used and proved by other operators. A new Dicalite Bulletin, now in preparation, covers the subject in detail . . . send in your name and we'll send you your copy as soon as it's printed.

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

DICALITE DIVISION · GREAT LAKES CARBON CORP. · 614 SO. FLOWER ST., LOS ANGELES 17, CALIF.

Here is a magneto that controls explosive fumes with "flame-proof" ventilation. The special ventilating arrangement of the Bendix Low-Tension Magneto permits air laden with explosive fumes to enter the magneto for ventilation without danger of igniting the surrounding air. Kits are also available to convert magnetos now in use to the "flame-proof" ventilation type.

In addition to this important safety feature Bendix Low-Tension Magnetos actually reduce engine maintenance and operating costs. For example, spark plug erosion is reduced to a minimum. The distribution of low tension voltage to the high tension coils is through a series of breaker assemblies, thus eliminating trouble often experienced with the conventional distributor. Variable or fixed sparks can be obtained by internal adjustment.

For safety and low operating costs it will pay you to specify Bendix Low-Tension for all your magneto requirements. Complete data available on request.

- **Low Plug Erosion Rate**
- **Breaker Type Distributor**
- **Ventilation without Fire Hazard**
- **Radio Shielding Available**
- **Variable or Fixed Ignition**

Bendix

SCINTILLA DIVISION OF
SIDNEY, NEW YORK

Bendix
AVIATION CORPORATION

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

FACTORY BRANCH OFFICES:

117 E. Providencia Avenue, Burbank, California • Stephenson Building, 6560 Cass Avenue, Detroit 2, Michigan
Brouwer Building, 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • 8401 Cedar Springs Road, Dallas 19, Texas

TRADE PERSONALS

W. W. Goode

G. J. Decker

Harry True

D. W. Cowart

J. A. Mullinax

▸ Schlumberger Well Surveying Corporation has announced changes in fiield and headquarters operations staffs. **W. W. Goode** has been appointed Permian Basin division manager at Midland, Texas. He replaced **George J. Decker** who was named South Louisiana division manager at Gretna. **Harry True** has been transferred from Gretna to Tulsa, Oklahoma, as assistant area manager. **P. P. Favier** is now assistant to the area manager at New Orleans, Louisiana, replacing **A. H. Curran,** who was named manager of the Western Canada division. **D. W. Cowart** is now technical assistant to the vice president, operations department, in the Houston, Texas, headquarters organization. **J. A. Mullinax** has been appointed assistant to the sales manager in Houston.

▸ **E. M. Bimberg** has been appointed general manager of the Zenith Carburetor division of Bendix Aviation Corporation. Previously, **G. C. Fricke** served as general manager of both the Zenith and Skinner divisions of Bendix. Bimberg joined the Zenith staff in 1916.

▸ Beaver Pipe Tools, Inc., Warren, Ohio, has announced that **Charles T. Everett** has been elected president and ganeral manager, as well as a director of the firm. Everett joined Beaver Pipe Tools, Inc., May 15, 1954, as executive vice president and ganeral manager.

▸ Dowell Incorporated has transferred three field engineers to the company's general office field development group in Tulsa, Oklahoma. The men are **J. L. Trittipo,** formerly station manager of Belle, West Virginia; **J. K. Crane,** formerly district engineer at Salem, Illinois; and **V. W. Grotlisch,** formerly sales engineer at Chicago Heights, Illinois. Each will carry the title of development engineer.

W. K. Holmes

G. W. Davidson

▸ **Will K. Holmes** has joined the sales staff of Master Tank & Welding, Dallas, Texas. He will specialize in the sale of anhydrous ammonia equipment.

▸ **D. E. Whittenberg** has been named general sales manager of Garrett Oil Tools, Inc. He is a vice president of the company and formerly was manager of its southern sales region. He will continue to maintain his office in Houston, Texas.

J. K. Crane

V. W. Grotlisch

J. L. Trittipo

D. E. Whittenberg

▸ **Ed T. Landgraff,** export sales manager of Chiksan Company's Newark, New Jersey, office, will make an extensive survey of Chiksan Export Company's expanding Latin American market from February through May of 1955. His itinerary will include Mexico, Panama, Colombia, Venezuela, Trinidad, Brazil, Argentina, Chile, Bolivia, Peru, and Ecuador.

▸ **Howard Murray,** formerly in charge of the Houston, Texas, office of Philadelphia Gear Works for four years, has been transferred to the main office in Philadelphia, Pennsylvania, to assume the duties of general manager of sales. Murray joined Philadelphia Gear Works in 1947 as a sales engineer.

▸ **Sam A. Wilson** has been named general manager of Dunham Tanks, as announced by Anderson-Dunham, Inc., parent company located in Baton Rouge, Louisiana.
Walter H. Cox has been appointed manager of Dunham Tanks' new Tulsa, Oklahoma, office.

▸ **Charles G. Hersh, director** of Atlas Powder Company's government ordnance works division, has retired after more than 35 years of service. He joined Atlas in 1919 as resident engineer at the firm's Reynolds, Pennsylvania, dynamite plant.

▸ The electoin of **P. O. Peterson** as president and chief executive of Mack Trucks, Inc., has been announced. **E. D. Bransome,** incumbent president and chairman of the board, is continuing as chairman.

Art Miller

Paul Hagaman

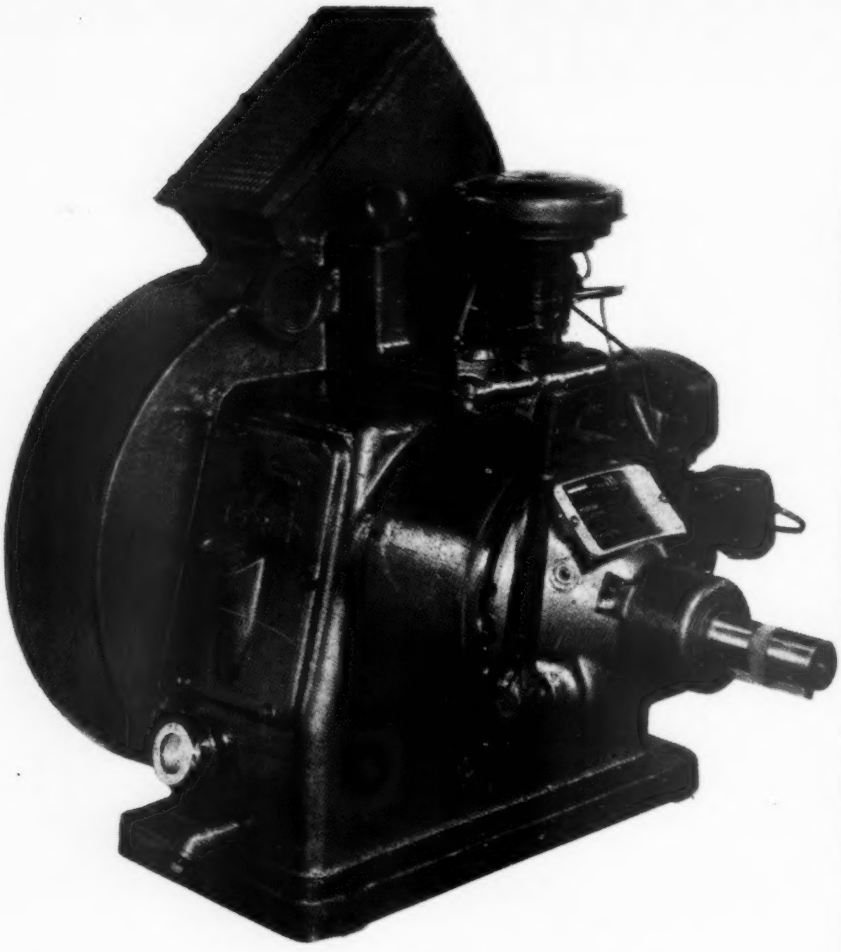
▸ W. C. Norris Company has announced the promotion of **G. W. (Bill) Davidson** to vice president in charge of sales. **Art Miller** was advanced from assistant sales manager to sales manager, and **Paul Hagaman,** Tulsa, Oklahoma, sales, became assistant sales manager.

▸ Byron Jackson Company has announced that **R. J. Evans, Jr.,** has been appointed Mid Continent regional sales manager for the Oil Tool division. Evans succeeded **B. A. Hilliard.** Evans is a 10-year member of the BJ Sales organization.

▸ Appointment of **A. Ray Wagner** as southwest district resident sales and service engineer is announced by The Swartwout Company. Wagner will work out of the Houston, Texas, regional office.

▸ **E. E. Rubac,** executive vice president and **W. R. Wheeler, Jr.,** assistant sales manager of the American Iron and Machine Works Company of Oklahoma City, Oklahoma, have recently returned from extensive tours of the Central and South American countries in the interest of increased export trade. Wheeler's trip included contacts in Argentina, Bolivia, Peru, and Equador while Rubac covered opcrations in Venezuela.

XUM



New LeRoi A114 Pumping Engine

A single-cylinder, valve-in-head engine with 114 cu. in. displacement, built specifically to give you economical operation with little attention.

Here it is — an engine that can pump more oil than any other engine of equal displacement. You can run it two weeks at a time without inspection, because the patented "vaporizing condensing" cooling system seldom needs make-up water. Moreover, a generous crankcase permits long intervals between oil changes, and there are no grease fittings, belts, or other accessories to need attention.

Performance is only half of the A114 story— the other half is dependability. Here are a few of the features that give the A114 its stamina:

The A114 operates on natural gas or LPG.

Get all the facts about this new 14.5 hp pumping engine from your supply house or your Le Roi distributor. Or, write for our latest bulletin E-8.

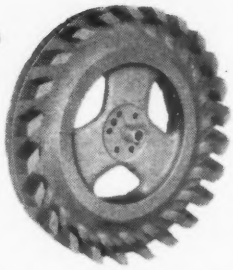
LE ROI *Division of Westinghouse Air Brake Co.*

Milwaukee 14, Wisconsin

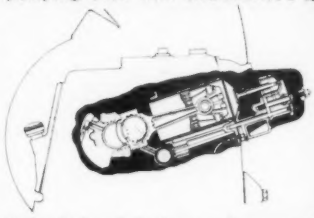
Oilfield Headquarters: Tulsa, Okla.

PORTABLE AIR COMPRESSORS • TRACTAIR • STATIONARY AIR COMPRESSORS • AIR TOOLS • ENGINES

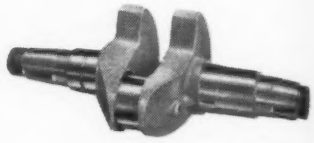
P-128



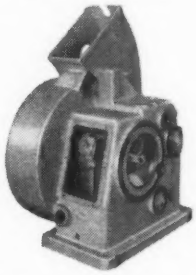
Two extra large flywheels provide generous WR2 values for smooth, constant-speed pumping even with unbalanced loads.



Valve-in-head design produces maximum power with minimum fuel consumption. Short stroke design reduces piston speed and lessens cylinder wear.

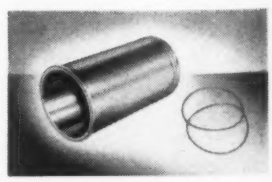


Short, counter-balanced crankshaft, 3" in diameter, has extreme overlap between crank pin and main bearing journals for added strength and rigidity.

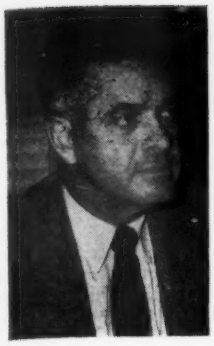


Heavily constructed and internally ribbed, integral crankcase and base eliminate any possibility of distortion.

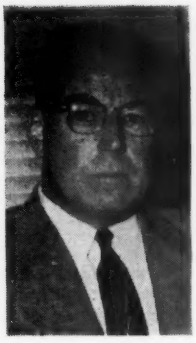
One-piece fan and flywheel is totally enclosed in a specially built air duct. No fan or belt to maintain or replace.



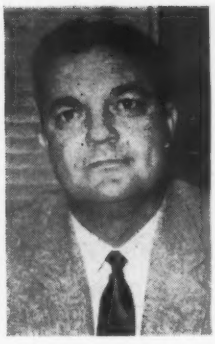
Removable, wet-cylinder sleeves assure easy, low-cost replacement of cylinder wearing surface.



W. F. Taylor



L. A. Myers



E. R. Phillips

J. D. Cleary

▸ Bethlehem Supply Company has announced the appointment of tubular sales managers for the northern, central and Gulf Coast divisions. **W. F. Taylor** has been appointed sales manager of the northern division and will continue to headquarter at Tulsa, Oklahoma. He has been with Bethlehem since September, 1936.

L. A. Myers has been appointed sales manager for the Gulf Coast division and will headquarter at the Houston, Texas, division office. Myers has been employed by Bethlehem since December, 1945. Most recently he has been a special representative working out of the Tulsa office.

E. R. Phillips has been appointed sales manager for the central division and will headquarter at the Dallas, Texas, sales office. He has been with Bethlehem since July, 1947, and most recently was store manager and field representative at the Gravville, Illinois, store.

Other Bethlehem promotions include **F. C. Beattie** to special representative for the Oklahoma district; **U. C. Blankenship,** store manager and field representative at Oklahoma City store; **H. M. Braymer** to machinery sales representative in West Texas-New Mexico; **D. G. Collins** to store manager and field representative at Grayville, Illinois, and **H. A. Sumrell, Jr.,** as local representative for the Ark-La-Tex district.

▸ Elliott Company, Jeannette, Pennsylvania, has announced the appointment of **O. M. Sievert** as its Kansas City district manager. Sievert joined the company in 1944 after graduating from the Missouri School of Mines.

▸ The Marmon-Herrington Company, Inc., has announced today that **Edward F. Ray** has been appointed general sales manager of its All-Wheel-Drive truck division. Ray will supervise a sales organization of Marmon-Herrington factory representatives and distributors in the United States and other countries.

▸ **Frank D. Potter** has been appointed assistant advertising manager of Childers Manufacturing Company, of Houston, Texas. Potter is a graduate of Southern Methodist University.

▸ Davison Chemical Company division of W. R. Grace & Company has appointed **Charles E. Meginnis** as district sales manager, industrial chemicals department. Meginnis has been resident field service engineer since July, 1953.

▸ **Dr. William Firestone** has recently been appointed to the newly created position of assistant chief engineer of the research department of Motorola's Communications and Electronics division. He received his Ph.D. in June, 1952, from Northwestern University.

▸ Appointment of **John D. Cleary** to operations divisions administrative assistant has been announced by The Western Company of Midland, Texas. Immediately before assuming his new Western position, Cleary was chief industrial engineer with Modine Manufacturing Company of Racine. Wisconsin.

▸ Iverson Supply Company announces the promotion of **Tom E. Bryant,** field salesman at Farmington, New Mexico, to store manager at Kermit, Texas.

▸ **Robert W. Humes,** advertising and sales promotion manager of Sherman Products, Inc., Royal Oak, Michigan, has been promoted to the position of assistant sales manager.

Donald C. Zuhlosdorff has been appointed assistant advertising and sales promotion manager for Sherman.

▸ **A. A. Mathewson** has been appointed assistant to the president of Borg-Warner Corporation's Petro-Mechanics research division, which is engaged in the development of a sonic oil well drill at North Hollywood, California. Mathewson is a mechanical engineering graduate of the California Institute of Technology.

▸ Duff-Norton Manufacturing Company has announced that **John J. Dixon** has succeeded **Frank H. Schwerin** as chief engineer. Dixon joined Duff-Norton in 1954.

▸ The Continental Supply Company has announced the appointment of **Roscoe O. Hambric** as assistant division manager of the Kansas-Oklahoma division, with headquarters in Tulsa, Oklahoma. Since January 1953, he had served as a district manager in Wichita, Kansas. Hambric started with Continental in the Seminole, Oklahoma, store in 1946. He has since held positions as city salesman, store manager and assistant district manager. He is a graduate of the University of Kansas.

Herbert P. Dawkins has been appointed credit manager of the Gulf Coast division with headquarters in Houston, Texas. Dawkins joined Continental at Longview, Texas in 1948.

John B. Barr will replace Dawkins as division credit manager at Shreveport. He joined Continental in February, 1950, and since 1952 has been in the credit department of the Oklahoma-Kansas division with headquarters in Tulsa.

J. K. Glenn was named district credit manager of the Rocky Mountain district with headquarters in Casper, Wyoming.

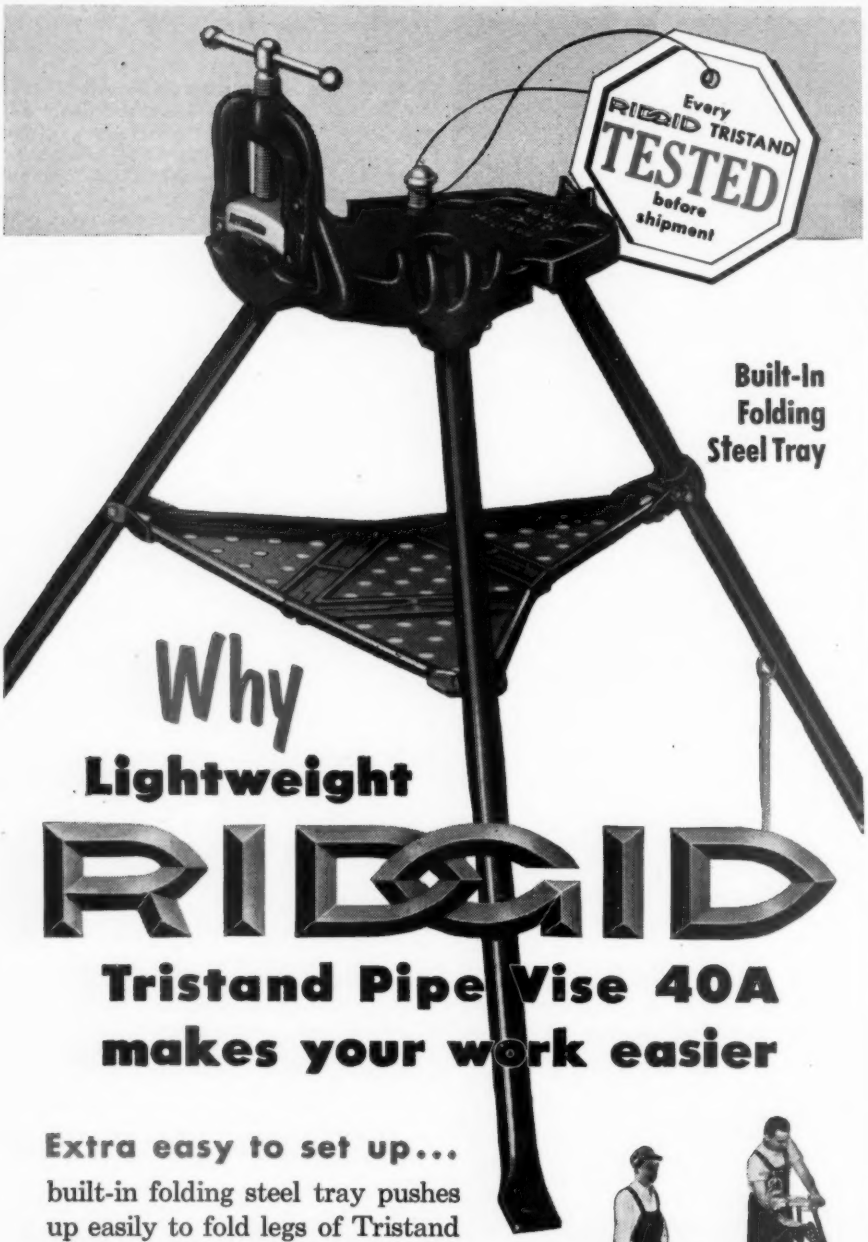
▸ Appointment of **C. G. Stupp** to the position of vice president, has been announced by Barrett division, Allied Chemical & Dye Corporation. Stupp has been technical director of Barrett since 1951, during which time the division's research and development activities have doubled. He was first employed by Barrett 38 years ago as a research chemist in the Edgewater plant.

▸ **Lance F. Ellis, Jr.,** has joined the sales department of Tuloma Gas Products Company. A graduate of the University of Tulsa, with a degree in petroleum engineering, Ellis will be a sales representative in Tuloma's refinery sales operations.

▸ **Henry Lee Martin** has been named general manager of national sales and distribution at Weatherford Oil Tool Company, Inc. Martin, who started his career in a pipe yard when 15, has been with Weatherford for the past 8 years.

The company also announced the promotion of **Robert Calvin (Bob) Yates** to manager of its eastern division at Harvey, Louisiana, succeeding Martin.

W. W. "Wes" Cothran, of Indianapolis, Indiana, receives the 1954 D. C. Ball Distinguished Service Award from John A. Carter, president of Oakite Products, Inc. Cothran has represented Oakite for the past 21 years. The award is given annually to the Oakite technical service representative who has rendered exceptional service to industry.



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Trade Personals

▸ The Wheland Company of Chattanooga, Tennessee, announced the appointment of **Tracy East** as service representative in the Texas gulf coast and Louisiana territories. East has been associated with the Houston Oil Field Material Company for many years and will continue to cooperate with that organization, servicing Wheland equipment.

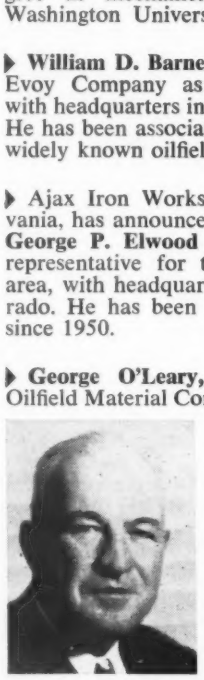
▸ Helmerich & Payne, Inc., has announced the appointment of **James R. Gregath** as a drilling engineer for the firm. Gregath is a mechanical engineering graduate of the University of Kansas.

▸ Lucey Products Corporation has announced the appointment of **William O. (Bill) Timberlake** as manager of machinery sales. Timberlake received his BS degree in mechanical engineering from Washington University in 1931.

▸ **William D. Barnett** has joined the McEvoy Company as sales representative with headquarters in Hobbs, New Mexico. He has been associated for ten years with widely known oilfield supply lines.

▸ Ajax Iron Works, of Corry, Pennsylvania, has announced the appointment of **George P. Elwood** as sales and service representative for the Rocky Mountain area, with headquarters in Denver, Colorado. He has been associated with Ajax since 1950.

▸ **George O'Leary,** president, Houston Oilfield Material Company, Inc., Houston, Texas, has been elected to serve a three year appointment as a director of the board of the National Association of Manufacturers. As a director he will attend board meetings and take part in the discussion of vital subjects, such as taxes, employment, union labor relations, industrial policies, general federal legislation, employer-employee relations, encouragement of the employment of the handicapped and other matters pertinent to the advancement of the National Association of Manufacturers.

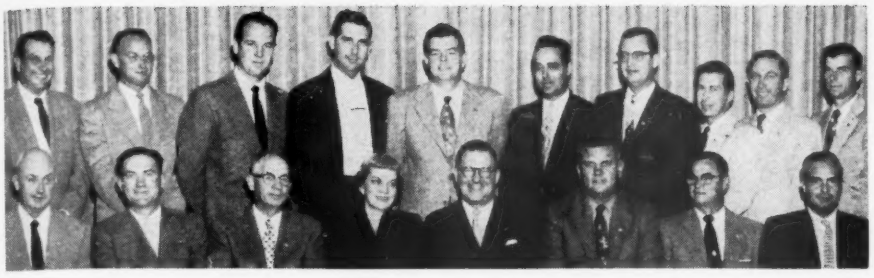

George O'Leary

▸ **E. L. Mohr, Jr.,** has been appointed manager, Pacific Coast division of Baroid division, National Lead Company. Mohr succeeded **W. L. Heater** who was appointed assistant to the manager drilling mud department. Mohr joined Baroid as a well logging engineer in August, 1941.

Jay P. Simpson has been appointed manager of the Gulf Coast sales and service lab of Baroid. Simpson was employed by Baroid in 1946 as a chemist in the products evaluation section of the Gulf Coast laboratory located in Houston, Texas.

▸ **John C. Bayless** is the newly appointed oil industry manager for Abrams Aerial Survey Corporation of Lansing, Michigan. He was educated at the University of Michigan where he received BS and MS degrees.

▸ **Cecil Laws** has been named district manager in Corpus Christi, Texas, for Hunt Tool Company. He is a graduate of Texas A & M with a BS degree in Petroleum Engineering.



Seventeen Hughes Tool Company employees were recently awarded service pins by M. E. Montrose, vice president, sales. Awards, made at Midland, Texas, went to, back row, Pete Connor, 20; Don Garrett, 5; Kenneth Lord, 5; R. T. McDaniel, 5; C. B. Fagans, 5; S. T. Crews, 5; Burney Stovall, 10; Charles Bumgardner, 5; Carl Townsend,5; Robert McCurry, 5. Front row, J. R. Kunkel, 10; G. A. Berglan, 10; R. E. Kimsey, 25; Maxine Mason, 5; M. E. Montrose; A. H. Linne, 10; Jack Steadman, 5; H. W. Benton, 5. Service pins were also won by J. B. Fanning, 10; Gus Henley, 10; W. H. Highberger, 5, and Pete Bailey, 5, not pictured.

▸ The Chicago Bridge and Iron Company announced the election of three new members to its board of directors. **George S. Trees,** assistant general sales manager, was elected to replace the late **Merle J. Trees. Fred Goldsby,** vice president and general sales manager, and **H. J. Clarke,** vice president and manager of erection, were elected as additional members of the board.

▸ Lane-Wells Company has announced the following executive and supervisory changes: **H. M. Rutledge, Jr.,** assistant to Gulf Coast division manager, has returned to his former assignment as division sales manager. **R. E. Bush,** Gulf Coast division sales manager, has been reclassified to assistant to Gulf Coast division manager. **W. A. Johnston,** assistant to Gulf Coast division manager, has been transferred to Wichita Falls, Texas, within the North Central Texas district as district superintendent.

A. L. Boyd, district superintendent in the North Central Texas district, has been made Houston district superintendent. **D. B. Wheeler,** district superintendent in the Houston district, has been made assistant to Gulf Coast division manager.

▸ **L. O. Geiger,** manager of the Dayton, Ohio, district of Air Reduction Sales Company, has retired. Geiger was with Air Reduction 38 years. **C. R. Grange,** assistant district manager, succeeded Geiger.

▸ **M. F. Hazel,** veteran sales and engineering executive of the Oil Well Supply Division of U. S. Steel Corporation, has been named vice president—sales. **Alex Quayle,** formerly chief engineer, succeeded Hazel.

Lloyd E. Tracy, former vice president—sales, was named vice president—merchandise; and **Dan H. Barr,** general merchandise manager, became assistant to vice president—sales. **Ralph W. Rager,** former vice president—administrative, was appointed vice president—manufacturing; and **Gordon M. Amstutz,** formerly general works manager, assumed the post of assistant to vice president—manufacturing.

▸ **Walther H. Feldmann,** formerly vice president in charge of sales of Worthington Corporation has been named executive vice president of the corporation. He succeeded **Edwin J. Schwanhausser** whose election as president of Worthington was announced earlier. **Thomas J. Kehane,** assistant vice president and general sales manager, succeeded Feldmann as vice president in charge of sales. **Charles A. Butcher** was named vice president for planning.

▸ The appointment of **Harold L. Blom** as manager of marketing administration for communication equipment has been announced by the General Electric Company. Blom will develop and carry out marketing administration programs and policies which include forecasting sales and scheduling production.

▸ De Laval Steam Turbine Company, Trenton, New Jersey, has named **D. T. Bixby** as sales manager of its standard products division.

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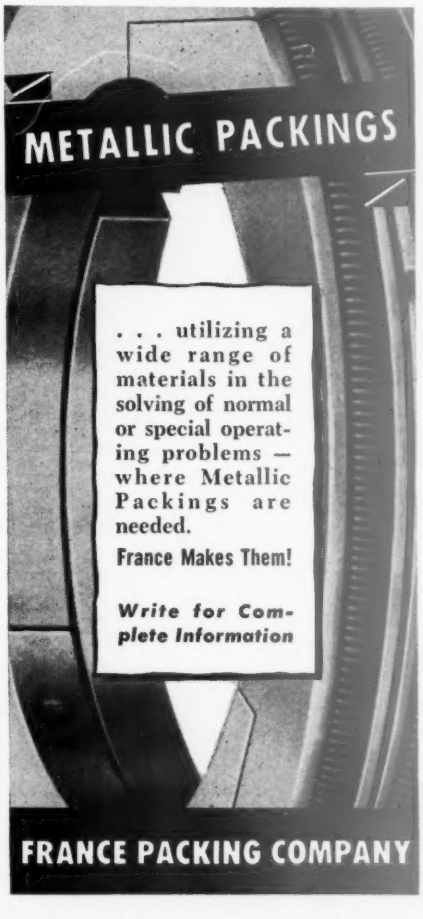
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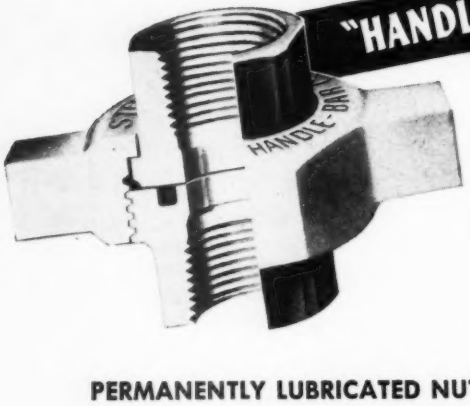

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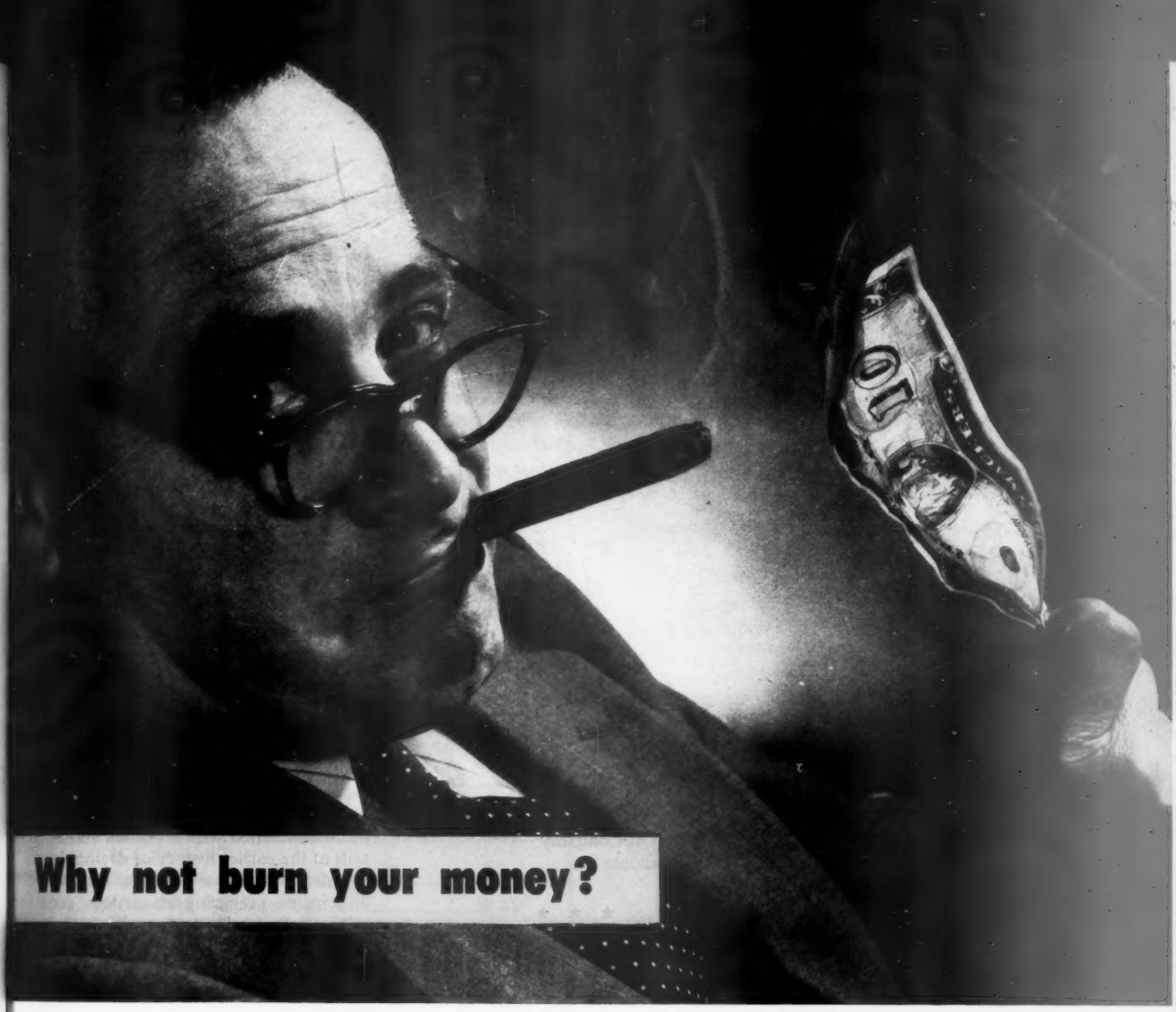

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LETTERS ★

"Red Tape" Draws Comment

We would like a quotation on reprint of 100 copies of the article, "Red Tape Can Choke Interstate Gas Sales," by Ernestine Adams, carried in the March, 1955, issue of *The Petroleum Engineer*. We consider the article very timely and applicable to our situation.

F. S. Workman, Jr.

Pond Fork Oil & Gas Company
Charleston, West Virginia

★ ★ ★

The article "Red Tape Can Choke Interstate Gas Sales" in March issue of *The Petroleum Engineer*, written by Ernestine Adams, is very good.

It seems to me that if someone would sponsor the printing of a quantity of copies and mailing of one of each to each Senator and Congressman in our national congress, it would help in getting rid of the regulation now in force.

E. L. Dawson

Kewanee Oil Company
Wirt, Oklahoma

★ ★ ★

That was indeed a dandy article on the red tape generated by federal control of natural gas. I am sure it will be brought to the attention of some of our congressmen and others, and I hope that they will get the opportunity to read it.

Charles E. Simons

General Gas Committee
Fort Worth, Texas

★ ★ ★

Congratulations on your fine article entitled, "Red Tape Can Choke Interstate Gas Sales." You have certainly approached the problem correctly from a producer's standpoint and have presented our case very realistically.

Jake L. Hamon

Dallas, Texas

★ ★ ★

Once again, you have come forth with an excellent article! I refer to "Red Tape Can Choke Interstate Gas Sales," which is very well done and should be of great benefit to us.

Frank M. Porter

American Petroleum Institute
New York, N.Y.

Drainhole Drilling Articles

The March issue of *The Petroleum Engineer* concluded a series of articles relative to the history of drainholes. These articles were most instructive and both Mr. J. B. Murdock, Jr., and Eastman Oil Well Survey should be complimented for their donation of historic information on the subject.

May it be brought to your attention and the attention of your readers, that the conclusion of the series ends the latter part of 1953, and since that time the Oilwell Drainhole Drilling Company has acquired from Eastman Oil the original Lee Patent.

Further, since the article was concluded in 1953, a greater number of drainholes have been drilled throughout the United States than the entire number referred to in these articles. Because of improvements in the tools and techniques, a great degree of success and acceptance has occurred that puts an entirely new light on the subject.

In lieu of the printed article being more concerned with statistics and details of the earlier history of drainholes, I understand *The Petroleum Engineer* anticipates preparing an article, containing information and results that will bring the reader currently up to date on this technique.

W. E. Sievers

Sievers Company
Long Beach, California

Editor's Note: The article mentioned in the last paragraph is in preparation and will be published in an early issue.

IDEA!

With all the history and records of oil and gas operations and progress that have been printed, it is still the personal accounts of struggle and failure and success that give the true picture of the oil industry.

The Oil Industry As I Saw It, the autobiography of W. L. Connelly, *The Great Wildcatter*, story of Mike Benedum, *Hugh Roy Cullen*, biography of the Houston independent — these are the books that thrill and inspire their readers. The story of H. L. Hunt is in preparation.

There are other men in the industry who have had wonderful experiences in this fascinating oil business. They also should look toward writing, or having some one else write, the exciting record of one man's life in the petroleum industry.